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ABRAHAM REES

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CYCLOPÆDIA:

OR, A NEW

UNIVERSAL DICTIONARY

OF

ARTS and SCIENCES.

Montgomeryshire

MONTGOMERYSHIRE, one of the counties of North Wales, is bounded on the E. and N.E by the county of Salop in England; on the S.E. by Radnorſhire; on the W. and S.W. by Merionethſhire and Cardiganſhire; and on the N. by Denbighſhire. It extends, according to the moſt accurate ſurveys, 35 miles in length, from the fartheſt point of Llangurig, on the borders of South Wales, to Piſtyll-Rhaiadr, a noted cataract in the Berwyn hills; and in breadth, from the town of Montgomery to that of Machynlleth, 30 miles. The ſuperficial area is variouſly ſtated; Templeman making it to compriſe 444,800 acres, while by other computation it is fixed as high as 560,000; and again, in a very recent ſurvey, at 491,600. Of this extent only 60,000 acres are under cultivation, and 18,000 laid down in paſturage; the remainder of the county is either in a waſte condition or is appropriated to woodlands.

The firſt inhabitants of this diſtrict, of whom mention is made in hiſtory, were a portion of the Ordovices, or Ordovicæ, whoſe territories extended at one time over the whole ſix counties of North Wales, with the exception of a ſmall part of Flintſhire, which belonged to the Carnabii. This people, naturally brave, and defended by the lofty hills and almoſt impaſſable ravines, with which their country abounds, contrived, notwithſtanding their deficiency in military ſkill, to baffle, for a period of two centuries, all the efforts of Roman diſcipline and courage to ſubdue them. Julius Agricola, the celebrated general of Domitian, however, at laſt effected, by his conſummate and indefatigable conduct, what his predeceſſors had in vain attempted; and not only compelled this county, but the moſt remote corner of Wales, to acknowledge and ſubmit to the Roman yoke. But though conquered, their ancient valour and love of country ſtill continued to animate them, ſo that no ſooner were the mighty conquerors of Europe forced to abandon their diſtant provinces and concentrate their troops for the defence of Italy, than the natives again aſſerted their independence. At this period, however, their country became divided into two ſeparate kingdoms, or principalities; of which Powiſland was, for many years, the moſt powerful and extenſive; and included Montgomeryſhire. During the heptarchy many deſperate battles were fought, either within this county, or on its borders; eſpecially in the reign of Offa, king of Mercia, who, having routed the Powyſians in ſeveral actions, compelled them to abandon all their poſſeſſions in Shropſhire; and in order the more effectually to reſtrain their incurſions, built the celebrated "dyke," which is ſtill viſible at the eaſtern boundary of the county Though thus reſtrained, however, the Powyſian monarchs, who now fixed their reſidence at Mathraval, in the vale of Meivod, ſtill continued to be objects of terror to their Mercian neighbours. The dyke of Offa was frequently a ſcene of the moſt dreadful carnage. At Buttington, the generals of the great Alfred completely deſtroyed a large body of Danes, who, having penetrated through Mercia, had poſted themſelves here upon the approach of the Saxon army. By this time the integrity of the kingdom of Powiſland had been again invaded, by its ſeparation into two ſmaller principalities, of which Montgomeryſhire alone formed that diſtinguiſhed by the name of Powis-Wenwynwyn. This diſtrict, ſubſequent to the Norman conqueſt, ſhared the fate of all the border counties, being compelled to ſubmit to the feudal domination of the lords marchers, after a long and deſperate ſtruggle to maintain its liberty. It ſtill continued, however, to be diſtinguiſhed by its ancient name, till the diviſion of Wales into counties, in the reign of Henry VIII., when it received the appellation of Montgomeryſhire, from the town of Montgomery, which forms the ſubject of the preceding article.

The greater proportion of this county aſſumes a mountainous characteriſtic. This is particularly the caſe with the midland, weſtern, and ſouth-weſtern parts, which are extremely bleak and unfavourable to cultivation. A range of

mountains, commonly diftinguifhed by the title of "the back-bone of Montgomeryfhire and Merionethfhire," commences in the fouth-weftern diftrict, and running nearly through the whole fhire, in a curvilinear direction, enters the county of Merioneth near Aran Fowddwy. The Freiddin, or Bridden hills, and the Long mountain, rear their lofty heads on the eaftern fide of the county, and form a natural boundary throughout their extent, between it and Shropfhire. The Biga mountains are feen on the north, ftretching themfelves along the northern fide of the valley of the Severn, till they reach a collateral ridge of Plinlimmon. Befides thefe there are numerous inferior ranges, ufually feparated by long narrow vallies and a few ifolated hills, which rife to a very confiderable height, like artificial mounts, in the centre of a level tract of country. The fubftrata of thefe hills vary, but not fo much as in the adjacent counties. Limeftone rarely enters into their compofition, except in the vicinity of Llanymech and Porthwaun, at both of which places a confiderable quantity of lime is wrought, chiefly for the purpofes of manure. Slate ftrata, on the other hand, are very abundant, and indeed conftitute the principal portion of all the mountains in the county, which are not pre-eminently lofty. Many quarries have been opened in different diftricts for the manufacture of this material, but the principal ones are confined to the hills around Llangynnog, where the beft flates, perhaps in England, are procured. From the elevated fituation of thefe quarries, the conveyance of the flates from thence to the plain below is a tafk of confiderable difficulty and hazard. The method in ufe here to accomplifh that object is not a little remarkable, and to an obferver unaccuftomed to the fight, muft appear fraught with extreme danger. The flates are placed on a fmall fledge, adapted to the work, which is faftened to the fhoulders of a man who has the care of delivering the cargo at the bafe of the mountain, by means of a rope, of which he lays faft hold with both hands, and then turning his face towards the load, he begins to move, gradually receding backwards till he reaches the bottom. Apparently dangerous, however, as this operation is, long experience has rendered it fo familiar to the workmen in general, that accidents are very uncommon; and to many of them it is equally eafy as conducting a common wheel-barrow on level ground. The other mineral productions of this county are coal, filver, lead and copper. The coal mines are only found, in any confiderable quantity, at Coedwae, on the borders of Salop. Silver is moft plentiful at Efgair-hir, where, as well as at Graig-y-Mwyn, near Piftyll-Rhaiadr, Dolydan weft from Llanbryn-Mair, and Llanydloes, lead mines have been opened. The only copper mine is fituated in the vicinity of Efgair-hir, on the confines of Cardiganfhire.

Montgomeryfhire is abundantly fupplied with rivers; indeed it may juftly be faid that more ftreams take their rife in this county than in any other of fimilar extent in Great Britain. Of thefe rivers the principal are the Severn, the Wye, the Vyrnwy, and the Tanat. The Severn, rifing on the fide of Plinlimmon hill, runs in a north-eafterly direction through a very confiderable portion of the county, and during its courfe receives the waters of feveral auxiliary ftreams. The Wye, which likewife has its fource from the fame ridge, taking a fouth-eaft direction, is joined by the Bedw rivulet at Llangerrig; whence flowing more to the fouth it foon enters Radnorfhire. The Vyrnwy rifes near Bwlch-y-Groes, and after a very changeable courfe, during which it is joined by the Tanat, falls into the Severn near Llandrinio. This river is remarkable for the multiplicity and variety of fifh which frequent it. Of thofe rivers which pafs through the county, but have their fprings in another, the principal are, the Maw, the Traethbach, the Cieriog, the Dee, and the Dovey: all of which will be found more particularly noticed in our account of the refpective counties to which they feem more properly to belong, under their appropriate names.

The climate of this county varies in different diftricts. In thofe parts which have been mentioned as more elevated than the reft, it is extremely cold and bleak; and in the narrow vallies the wind is almoft conftantly high, and very frequently boifterous. The wefterly winds are prevalent during nine months of the year, and the eafterly the remaining three. Thefe laft are ufually accompanied with fleet and rains, but feldom blow fo ftrong as thofe from the S.W. or N.W. which commonly prove fatal to the fruit both on the higher grounds and in the vallies. The foil of the mountains here, partaking of the nature of their fubftrata, is for the moft part of a fchiftofe kind; that in the vales was doubtlefs originally of the fame defcription, but in confequence of cultivation now approaches very nearly to a clayey fubftance.

It has already been obferved, that not above one-half of Montgomeryfhire is in a ftate of cultivation, the reft being either covered with wood, or lying in a wafte condition. Of the cultivated lands, about one-third has been mentioned as arable; the other two-thirds being ufually laid down with grafs. The moft common arable crops are oats, barley, wheat and rye. Hemp is likewife grown in confiderable quantity in the eaftern divifion of the county; almoft every cottage having what is called a hemp-yard attached to it. Of the grafs lands only a fmall portion, compared with their extent, are fufficiently fertile to be adapted for fattening cattle. Indeed that object is feldom attempted, except in fome particular fpots in the vales of the Severn, and of the Vyrnwy. The woodlands comprehend feveral very valuable and extenfive plantations. Montgomeryfhire, in fact, is ftill by far the beft wooded county in Wales, and was formerly regarded as a valuable depôt of oak for the ufe of the navy. Within the laft fifty years, however, large quantities of that noble tree have been felled; and fo little care taken to replace them, that the county has nearly loft all its importance in this refpect. The wafte lands here are chiefly appropriated to the grazing of oxen, fheep, and horfes. The oxen are of different breeds, each of which have their provincial peculiarities. Thofe of the native breed, which are ufually termed the finch-backed kind, are of a brindled colour, fhort in the leg, and of great depth in the carcafe. Thofe originally from Devonfhire have, on the other hand, long legs, and a more compact body, and are confequently better fitted for agricultural purpofes than the native fort. A kind from Hereford, diftinguifhed by their white faces, have of late years become very prevalent in the eaftern diftrict. Of fheep there are two kinds; the one peculiar to the Kerry hills, and the other chiefly bred on the ridge called Long-Mountain, and fome other hills on the borders of Shropfhire. The firft of thefe breeds is fuppofed to be the only variety in Wales which produces perfect wool; that of the other breeds being ufually more or lefs debafed by the intermixture of coarfe long hairs, denominated by dealers kemps. Its difcriminating characteriftics are large wide cheeks, covered with wool, a bunchy fore-head, deftitute of horns, white woolly legs, and a broad beaver-like tail. The fecond kind alfo affords wool of a fuperior quality, but in much lefs quantity. Horfes of very different fizes and properties are reared in Montgomeryfhire. The hilly diftricts are remarkable for a race of fmall ponies, called merlyns, which being left to range over the mountains, as well during winter as fummer, till at leaft three years old, are in confequence a very hardy race. Thefe are chiefly ufed as beafts of burthen, by the numerous packmen who traverfe the country to collect the

manufactured articles, or to fell others which the inhabitants may require. For this purpofe they are extremely well fitted, cuftom having taught them to climb the rugged and flippery afcents with a firm and fteady ftep; and it is on that account much to be lamented, that the neglected ftate in which they are allowed to remain has materially deteriorated the breed. A larger kind of horfe, apparently a crofs between the merlyn and the Englifh breed, is likewife a native of the hilly diftricts in Montgomeryfhire. The moft fizeable of thefe animals are admirably adapted for the team on the higher grounds, where heavier horfes would be egregioufly mifapplied; and the leffer ones make good roadfters with a light weight. A third breed, of a very fuperior quality to either of thefe, is alfo reared in the more fertile vales here, which fome fay was introduced from Spain by Robert, earl of Shrewfbury. Queen Elizabeth is further ftated to have greatly affifted in perpetuating this breed, by keeping a famous ftud of horfes and brood mares at Park, in this county.

The chief, or rather the only, manufactured production of Montgomeryfhire, is flannel; for though hemp, as has been already faid, is grown here in confiderable quantity, it is feldom made into any article of ufe, till it has paffed into the hands of the manufacturers of other diftricts. In former times, the only machinery employed in the manufacture of the flannel was the common weaving machine; all the procefs of carding the wool, and fpinning into thread, having been executed, in the moft literal fenfe of the term, by the tedious operation of the hand, by farmers and cottagers in their own houfes. Of late years, however, the powerful aid of more complicated apparatus has likewife been reforted to; and there are now upwards of forty carding, and feveral fpinning machines, driven by water, in different parts of the county. The moft extenfive manufactories for weaving are thofe at Newtown, Berhiew, Welfh-Pool, and Dolydran; and one on the Dulas ftream, near Machynlleth, at which, however, cloths are made as well as flannels. Of thefe laft the finer pieces generally meafure about 132 yards, and the inferior ones 110: and as 500 pieces of either kind are frequently fold at the weekly markets, it does not feem to be exceeding truth to average their amount at 300, thereby making the whole annual produce fold out of the county 7800 pieces; which, calculated at the low average of 8*l.* a piece, gives the fum of 62,400*l.* as the total profit arifing therefrom, including the value of wool, which may be fuppofed worth fomething more than 18,000*l.*

The roads in this county are, perhaps without exception, the worft within the limits of North Wales, efpecially in the vallies; but this deficiency does not arife fo much from any neglect on the part of the proprietors to their formation or repair, as from the want of fuitable materials for the purpofe; there being no granite or other indurated rock here, as in the other counties, which could be employed to render them firm and compact. They are confequently moft commonly formed of the fhale and flate ftones, of which it has been remarked that the mountains are chiefly compofed; and thefe foft and friable fubftances foon become reduced, by the preffure and friction they neceffarily fuftain, to their primitive clay. Hence the roads, even in fummer, are often moift and flippery; and in winter are fo deep and clammy, as to be nearly impaffable for carts of a heavy burthen. But to the honour of the county, though the roads are thus unavoidably of a bad texture, the bridges are generally excellent, and more numerous than thofe of any other county in the principality, when confidered in reference to the comparative extent of its cultivated lands.

Many interefting remains of antiquity of various defcriptions have been difcovered or traced, at different periods within the limits of Montgomeryfhire. The Roman ftation, Mediolanum, is fixed by feveral able antiquaries in the vicinity of Meifod, or Meivod, which, as noticed above, afterwards became the refidence of the Powyfian monarchs. The ftation Maglona is likewife, with great probability, placed at or in the vicinity of Machynlleth, as many veftiges of walls, and the remains of two forts evidently Roman, are ftill diftinctly vifible there. Many Roman coins have alfo been dug up at this place; and two miles from it is a fpot, yet retaining the appellation of Cefn Caer, or the back part of the city. Machynlleth afterwards became noted as the town where the celebrated Owen Glyndwyr affembled the eftates of Wales in 1402, when his title to the principality was folemnly acknowledged. The fenate houfe, in which this convocation was held, is now degraded, by being converted into a ftable; but its fpacious door-way fufficiently evinces its occupancy to have been once more honourable. (See MACHYNLLETH.) At Montgomery are the ruins of the celebrated caftle of that name; and clofe to it is a Britifh and a Saxon encampment, the former remarkable both for its ftrength and extent. On the weft fide of the road from this town to that of Newtown ftands the ancient fortrefs of "Dolforwyn-Caftle," faid by Dugdale to have been the work of Dafydd-ap-Llewelyn, a prince who reigned from the year 1240 to 1246; but referred by a Welfh writer, John Dafydd Rhys, to a much earlier date. Caer-Sws, or Caers-goofe caftle, on the north bank of the Severn, is confidered by fome to have been a Roman ftation, though not mentioned in any of the Itineraries. Extenfive traces of buildings, ranged in ftreets interfecting each other at right angles, have been difcovered in the fields, adjacent to the village. Two encampments are fituated at a little diftance, where fome infcribed bricks have been dug up; and clofe to them appear confiderable veftiges of a Roman road, running in a direction from Caer-Sws to Meifod. Several encampments, both Roman and Britifh, are likewife difcovered in the neighbourhood of Llanfair and Welfh-Pool. Near the latter town was fituated the abbey of Yftrat-Marchell, founded in 1170, for monks of the Ciftercian order. A mile from hence is Powis caftle, a venerable manfion, conftructed of red fand-ftone, and ftanding on the ridge of a lofty rock. This caftle makes a confiderable figure on the pages of hiftory, and is now the chief feat of the noble family of Clive, to which the adjoining village gives the title of marquis. (See WELSH-POOL.) Befides thefe, many other relics of antiquity in Montgomeryfhire might be noticed, would the limits of an article like the prefent allow of greater digreffion; but as that cannot be permitted, we fhall only further mention the "Dyke of Offa," which runs nearly through the whole eaftern fide of the county, and which is juftly ranked among the moft extraordinary efforts of human labour in Great Britain.

Montgomeryfhire, in a political point of view, is divided into nine hundreds, comprifing forty-nine parifhes, one borough-town, Montgomery, and fix market-towns, *viz.* Welfh-Pool, Llanfyllin, Llanfair, Machynlleth, Newtown, and Llanydloes. The names of the hundreds are Llanfyllin, Deuddwr, Pool, Cawrfe, Mathrafal, Machynlleth, Llanydloes, Newtown, and Montgomery. This county fends two reprefentatives to parliament, one as knight of the fhire, and another as burgefs for the borough. Its honorial diftinctions are confined to two families; that of Clive, already mentioned, and that of Herbert, which holds the dignity of earl of Pembroke and Montgomery. By the returns made to parliament in 1801, the amount of its population was 47,978 perfons, *viz.* 22,494 males, and 25,064 fe-

males; of which number, 6233 were reported as employed in the various departments of trade and manufacture, and 13,082 in the labours of agriculture. The money raifed here for the ufe of the poor, in 1803, amounted to the fum of 22,988*l.* In refpect to ecclefiaftical jurifdiction, the whole county is included within the province of Canterbury, but is divided among the three diocefes of Bangor, Hereford, and St. Afaph. Davies's Agricultural Report of North Wales, 8vo. Beauties of England and Wales, by Mr. Evans, vol. xvii. Wynne's Hiftory of Wales.

Moor-stone

Moor-*Stone*, the name of a very remarkable ftone found in Cornwall, and fome other parts of England, and ufed in the coarfer works of the prefent builders.

This is truly a white granite, and is a very valuable ftone. It is very coarfe and rude, but has beautiful congeries of varioufly conftructed and differently figured particles, not diffufed among, or running into, one another, but each pure and diftinct, though firmly cohering with whatever it comes in contact with. Its colours are principally black and white; the white are of a foft, marbly texture, and opaque, formed into large congeries, and emulating a fort of tabulated ftructure; among thefe are many of a pure cryftalline fplendour and tranfparence; and in fome are lodged in different directions many fmall flaky maffes of pure talcs of feveral colours; fome are wholly pellucid, others of an opaque white, others of the colour of brown cryftal, and a vaft number perfectly black. It is found in immenfe ftrata in fome parts of Ireland, but is difregarded there.

It is found with us in Devonfhire, Cornwall, and fome other counties; and brought thence in vaft quantities to London. It never forms any whole ftrata there, but is found on the furface of the earth in immenfe and unmanageable maffes; and to feparate thefe into portable ones, they dig a hole with a wedge in fome part of them, and furrounding it with a ridge of clay they fill it up with water; this by degrees foaks in, and finding its way into the imperceptible cracks, fo far loofens the cohefions of the particles there, that the day after they drive a larger wedge into the hole, and the ftone breaks into two or more pieces. It is ufed in London for the fteps of public buildings; and on other occafions, where great ftrength and hardnefs are required.

The people of Cornwall, who have this ftone in great plenty, ufe it in their tin-works, and particularly in their tin-kiln, on the good effect of which a great deal depends. This kiln is four-fquare, and at its top is placed a large block or moor-ftone; the ufual fize of this block is fix feet in length, and four in breadth. In the middle of this block there is made a hole of about fix inches in diameter. This ftone ferves as a head to cover another like ftone placed beneath it; but this under one is not fo long as the upper by fix inches. The reafon of this is, that it muft not reach the innermoft or back part of the wall, which is the open place through which the flame afcends from another place below that, where a very ftrong fire of furze is conftantly kept up; and there is another little hole alfo on the outfide. The fore-part is like a common oven, and has fuch a fort of chimney.

The tin-ore is roafted in this kiln, to burn away the mundic, in this manner: the ore is brought in powder, and poured out in heaps on the furface of the top-ftone; a man ftands there, and thrufts it down through the hole in this ftone into the kiln, that is, to the furface of the under-ftone: a perfon who ftands below fpreads this as it falls with an iron rake, and gives notice to the perfon above when there is enough down, that is, when the furface of the lower ftone is covered three or four inches thick. When this is done, the hole at the top is covered with green turfs, that the flame may reverberate the ftronger; and the heat that the moor-ftone acquires helps to roaft the ore: while the flame that comes up from the ore is blue, there yet remains mundic among it; but when this is burnt off, the flame is yellow. Phil. Tranf. N° 69.

The miners in fome parts of Cornwall ufe the name moor-ftone for a fort of coarfe free-ftone, which lies very often over the tin-ore: this is of a greyifh colour, and is fomewhat fofter than that ufually employed in building. See Growan.

Mortar

MORTAR, or MORTER, in *Architecture*, a compoſition of lime, ſand, &c. mixed up with water: ſerving as a cement to bind the ſtones, &c. of a building.

The ancients had a kind of mortar ſo very hard and binding, that, after ſo long a duration as to this time, it is next to impoſſible to ſeparate the parts of ſome of their buildings; though there are ſome who aſcribe that exceſſive ſtrength to time, and the influence of certain properties in the air, which is, indeed, found to harden ſome bodies very ſurpriſingly.

The lime uſed in the ancient mortar, is ſaid to have been burnt from the hardeſt ſtones, or often from fragments of marble.

De Lorme obſerves, that the beſt mortar is that made of pozzolana for ſand; adding, that this penetrates black flints, and turns them white. See POZZOLANA, and *Puteolanus* PULVIS.

Mr. Worledge obſerves, that fine ſand makes weak mortar, and that the larger the ſand the ſtronger the mortar. He therefore adviſes, that the ſand be waſhed before it is mixed; and adds, that dirty water weakens the mortar conſiderably.

Wolfius obſerves, that the ſand ſhould be dry and ſharp, ſo as to prick the hands when rubbed; yet not earthy, ſo as to foul the water in which it is waſhed.

Vitruvius obſerves, that foſſile ſands dry ſooner than thoſe taken out of rivers. Whence he adds, the latter is fitted for the inſides, the former for the outſides of a building. He ſubjoins, that foſſile ſand, lying long in the air, becomes earthy. Palladio takes notice, that of all ſands white ones are the worſt; and the reaſon is owing to their want of aſperity.

The proportion of lime and ſand in our common mortar is extremely variable: Vitruvius preſcribes three parts of pit-ſand, and two of river-ſand, to one of lime; but the quantity of ſand here ſeems to be too great.

The proportion moſt commonly uſed in the mixing of lime and ſand is, to a buſhel of lime a buſhel and a half of ſand, *i. e.* two parts of lime and three of ſand; though the common mortar, in and about London, has more ſand in it than according to this proportion. The improvement of mortar is certainly an object of great importance: and different ſchemes have been ſuggeſted for giving it that degree of durability for which the mortar uſed by the ancients is ſo juſtly celebrated.

Mr. Doſſie, in the ſecond volume of the Memoirs of Agriculture, p. 20, &c. gives the following method of making mortar impenetrable to moiſture, acquiring great hardneſs, and exceedingly durable, ſimilar to that uſed by the ancients, which was diſcovered by a gentleman of Neufchatel: take of unſlaked lime and of fine ſand, in the proportion of one part of the lime to three parts of the ſand, as much as a labourer can well manage at once; and then adding water gradually, mix the whole well together with a trowel, till it be reduced to the conſiſtence of mortar. Apply it immediately, while it is hot, to the purpoſe, either of mortar, as a cement to brick or ſtone, or of plaſter to the ſurface of any building. It will then ferment for ſome days in drier places, and afterwards gradually concrete, or ſet, and become hard: but in a moiſt place it will continue ſoft for three weeks or more; though it will, at length, attain a firm conſiſtence, even if water have ſuch acceſs to it ſo as to keep the ſurface wet the whole time. After this, it will acquire a ſtone-like hardneſs, and reſiſt all moiſture. The perfection of this mortar depends on the ingredients being thoroughly blended together; and the mixture being applied immediately after to the place where it is wanted. The lime for this mortar muſt be made of lime-ſtone, ſhells, or marle; and the ſtronger it is, the better the mortar will be; beſides, the lime ſhould be carefully kept from the acceſs of air or wet; otherwiſe, by attracting moiſture, it will loſe proportionably that power of acting on the ſand, by which the incorporation is produced. It is proper alſo to exclude the ſun and wind from the mortar, for ſome days after it is applied; that the drying too faſt may not prevent the due continuance of the fermentation, which is neceſſary for the action of the lime on the ſand. When a very great hardneſs and firmneſs are required in this mortar, the uſing of ſkimmed milk inſtead of water, either wholly or in part, will produce the deſired effect, and render the mortar extremely tenacious and durable.

M. Loriot's mortar, the method of making which was announced by order of his majeſty at Paris in 1774, is made in the following manner: take one part of brick-duſt finely ſifted, two parts of fine river-ſand ſkreened, and as much old ſlaked lime as may be ſufficient to form mortar with

water, in the usual method, but so wet as to serve for the slaking of as much powdered quick-lime as amounts to one-fourth of the whole quantity of brick-dust and sand. When the materials are well mixed, employ the composition quickly, as the least delay may render the application of it imperfect or impossible. Another method of making this composition is to make a mixture of the dry materials; *i.e.* of the sand, brick-dust, and powdered quick-lime, in the prescribed proportion; which mixture may be put in sacks, each containing a quantity sufficient for one or two troughs of mortar. The above-mentioned old slaked lime and water being prepared apart, the mixture is to be made in the manner of plaster, at the instant when it is wanted, and is to be well chafed with the trowel. With respect to this method, Dr. Higgins observes, that M. Loriot corrects the bad quality of the old and effete lime, which constitutes the basis of his mortar, and which has regained a part of the fixed air that had been expelled from it, by the addition of fresh and non-effervescent lime, hastily added to it, at the time of using the composition, which must undoubtedly improve the imperfect mass. And he adds, that when an ignorant artist makes mortar with whiting instead of lime, he can mend it considerably by adding lime to it; but his mortar will still be defective, in comparison with the best that may be made, by reason of the old slaked lime or whiting; this on repeated trials he has found to be the true state of the case. Dr. Higgins has made a variety of experiments, in consequence of the modern discoveries relating to fixed air, for the purpose of improving the mortar used in our buildings. According to this author, the perfection of lime, prepared for the purpose of making mortar, consists chiefly in its being totally deprived of its fixed air. On examining several specimens of the lime commonly used in building, he found that it is seldom or never sufficiently burned; for they all effervesced, and yielded more or less fixed air, on the addition of an acid, and slaked slowly, in comparison with well burned lime. Dr. Higgins also relates some experiments, which shew how very quickly lime imbibes fixed air from the atmosphere; on its exposure to which it by degrees soon loses those characters which chiefly distinguish it from mere lime-stone or powdered chalk: by soon attracting from thence that very principle, to the absence of which it owes its useful quality as a cement, and which had before been expelled from it in the burning. Hence he concludes, that, as lime owes its excellence to the expulsion of fixed air from it in the burning, it should be used as soon as possible after it is made, and guarded from exposure to the air, as much as possible, before it is used. It is no wonder, therefore, he says, that the London mortar is bad, if the imperfection of it depended solely on the badness of the lime; since the lime employed in it is not only bad when it comes fresh from the kiln, because it is insufficiently burned, and the air has access to it, but becomes worse before it is used, by the distance and mode of its conveyance, and when slaked, is as widely different from good lime, as it is from powdered chalk. For a similar reason, every other cause, which tends to restore to the lime the fixed air, of which it had been deprived in the burning, must deprave it. It must receive this kind of injury, for instance, from the water, so largely used, first in slaking the lime, and afterwards in making it into mortar; if that water contains fixed air, from which few waters are perfectly free, and which will greedily be attracted by the lime. The injury arising from this cause is prevented by the substitution of lime-water, so far as may be practicable or convenient.

From other experiments, made with the view of ascertaining the best relative proportions of lime, sand and water, in the making of mortar, it appeared that those specimens were the best which contained one part of lime in seven of the sand; for those which contained less lime, and were too short whilst fresh, were more easily cut and broke, and were pervious to water; and those which contained more lime, although they were closer in grain, did not harden so soon, or to so great a degree, even when they escaped cracking by lying in the shade to dry slowly. It appeared farther, that mortar, which is to be used where it must dry quickly, ought to be made as stiff as the purpose will admit, or, with the smallest practicable quantity of water, and that mortar will not crack, although the lime be used in excessive quantity, provided it be made stiffer, or to a thicker consistence than mortar usually is.

Dr. Higgins has also shewn, that though the setting of mortar, as it is called by the workmen, chiefly depends on the exsiccation of it, yet its induration, or its acquiring a stony hardness, is not caused by its drying, as has been supposed, but is principally owing to its absorption of fixed air from the atmosphere, and is promoted in proportion as it acquires this principle; the accession of which is indispensibly necessary to the induration of calcareous cements. In order to the greatest induration of mortar, therefore, it must be suffered to dry gently and set; the exsiccation must be effected by temperate air, and not accelerated by the heat of the sun or fire; it must not be wetted soon after it sets; and afterwards it ought to be protected from wet as much as possible, until it is completely indurated; the entry of acidulous gas must be prevented as much as possible, until the mortar is finally placed and quiescent; and then it must be as freely exposed to the open air as the work will admit, in order to supply acidulous gas, and enable it sooner to sustain the trials to which mortar is exposed in cementitious buildings, and incrustations.

Dr. Higgins has also enquired into the nature of the best sand or gravel for mortar, and into the effects produced by bone-ashes, plaster powder, charcoal, sulphur, &c. and he deduces great advantages from the addition of bone-ashes, in various proportions, according to the nature of the work for which the composition is intended.

This author describes a water-cement or stucco, of his own invention, for incrustations internal and external, exceeding, as he says, Portland stone in hardness, for which he obtained his majesty's letters patent in 1779. As for the materials of which this is made; drift sand, or quarry sand, or, as it is commonly called, pit sand, consisting chiefly of hard quartose flat-faced grains, with sharp angles, the most free from clay, salts, and calcareous, gypseous, or other grains, less durable than quartz, containing the smallest quantity of pyrites, or heavy metallic matter, inseparable by washing, and admitting the least diminution in bulk by washing, is to be preferred to any other. The sand is to be sifted in streaming clear water, through a sieve which shall give passage to all such grains as do not exceed one sixteenth of an inch in diameter: and the stream of water and sifting are to be so regulated, that all the sand, which is much finer than the Lynn sand, together with clay and other matter, specifically lighter than sand, may be washed away with the stream; whilst the purer and coarser sand, which passes through the sieve, subsides in a convenient receptacle; and whilst the coarse rubbish and shingle remain on the sieve to be rejected. The subsiding sand is then washed in clean streaming water, through a finer sieve, so as to be farther cleansed and sorted into two parcels, a coarser, which will remain in the sieve which is to give passage to such grains of sand only as are less than one thirtieth of an inch in diameter, and which is to be saved apart

under the name of coarse sand; and a finer, which will pass through the sieve and subside in the water, and which is to be saved apart under the name of fine sand. These are to be dried separately, either in the sun, or on a clean iron plate set on a convenient surface, in the manner of a sand heat. Let the lime be chosen, which is stone-lime, which heats the most in slaking, and slakes the quickest when duly watered; which is the freshest made and most closely kept; which dissolves in distilled vinegar with the least effervescence, and leaves the smallest residue insoluble, and in this residue the smallest quantity of clay, gypsum, or martial matter. Let this lime be put in a brass-wired fine sieve, to the quantity of fourteen pounds. Let the lime be slaked by plunging it in a butt, filled with soft water, and raising it out quickly and suffering it to heat and fume, and by repeating this plunging and raising alternately, and agitating the lime, until it be made to pass through the sieve into the water: reject the part of the lime that does not easily pass through the sieve; and use fresh portions of lime, till as many ounces of lime have passed through the sieve as there are quarts of water in the butt. Let the water, thus impregnated, stand in the butt, close covered, until it becomes clear; and, through wooden cocks placed at different heights in the butt, draw off the clear liquor, as fast and as low as the lime subsides, for use. This clear liquor is called the cementing liquor. Let fifty-six pounds of the foresaid chosen lime be slaked, by gradually sprinkling on it, and especially on the unslaked pieces, the cementing liquor, in a close clean place. Let the slaked part be immediately sifted through the fine brass-wired sieve. Let the lime which passes be used instantly, or kept in air-tight vessels, and let the part of the lime which does not pass through the sieve be rejected: the other part is called purified lime. Let bone-ash be prepared in the usual manner by grinding the whitest burnt bones; but let it be sifted to be much finer than the bone-ash commonly sold for making cupels. Having thus prepared the materials, take fifty-six pounds of the coarse sand, and forty-two pounds of the fine sand; mix them on a large plank of hard wood placed horizontally: then spread the sand so that it may stand to the height of six inches, with a flat surface on the plank; wet it with the cementing liquor; to the wetted sand add fourteen pounds of the purified lime, in several successive portions, mixing and beating them up together; then add fourteen pounds of the bone-ash in successive portions, mixing and beating all together. This Dr. Higgins calls the water-cement coarse-grained, which is to be applied in building, pointing, plastering, stuccoing, &c. observing to work it expeditiously in all cases, and in stuccoing to lay it on by sliding the trowel upwards upon it; to well wet the materials used with it, or the ground on which it is laid, with the cementing liquor, at the time of laying it on; and to use the cementing liquor for moistening the cement and facilitating the floating of it.

If a cement of a finer texture be required, take ninety-eight pounds of the fine sand, wet it with the cementing liquor, and mix it with the purified lime and the bone-ash as above, with this difference, that fifteen pounds of lime are to be used instead of fourteen pounds, if the greater part of the sand be as fine as Lynn sand. This is called water-cement fine-grained; and is used in giving the last coating or the finish to any work, intended to imitate the finer grained stones or stucco. For a cheaper and coarser cement, take of coarse sand or shingle fifty-six pounds, of the foregoing coarse sand twenty-eight pounds, and of the finer sand fourteen pounds; and after mixing and wetting these with the cementing liquor, add fourteen pounds, or somewhat less, of the purified lime, and then as much of the bone-ash, mixing them together. When the cement is required to be white, white sand, white lime, and the whitest bone-ash are to be chosen. Grey sand, and grey bone-ash, formed of half-burnt bones, are to be chosen to make the cement grey; and any other colour is obtained, either by chusing coloured sand, or by the admixture of the necessary quantity of coloured talc in powder, or of coloured vitreous or metallic powders, or other durable colouring ingredients, commonly used in paint. The water-cement above described is applicable to forming artificial stone; by making alternate layers of the cement and of flint, hard stone, or brick, in moulds of the figure of the intended stone, and by exposing the masses so formed to the open air to harden. When it is required for water fences, two-thirds of the bone-ashes are to be omitted, and in its stead an equal measure of powdered terras is to be used. When the cement is required of the finest grain, or in a fluid form, so that it may be applied with a brush, flint powder, or the powder of any quartose or hard earthy substance, may be used in the place of sand, so that the powder shall not be more than six times the weight of the lime, nor less than four times its weight. For inside work, the admixture of hair with the cement is useful. Higgins's Exp. and Obs. on Calcareous Cements, &c. 8vo 1780, passim. See STUCCO.

MORTAR, *Mixing and Blending of*. M. Felibien observes, that the ancient masons were so very scrupulous in this process, that the Greeks kept ten men constantly employed, for a long space of time, to each bason; this rendered the mortar of such prodigious hardness, that Vitruvius tells us the pieces of plaster falling off from old walls served to make tables. The same Felibien adds, it is a maxim among old masons to their labourers, that they should dilute with the sweat of their brow, *i. e.* labour it a long time, instead of drowning it with water to have done the sooner.

MORTAR-*Mill*, in *Rural Economy*, a machine contrived by Mr. Supple, for the purpose of saving labour in the making up of mortar, as well as doing the business more effectually and at a trifling expence. It may also be useful in working clay, &c.

And the mode of doing it is thus described by the inventor: "A pit is dug in the ground, which is bricked at the bottom and sides, into which the operator puts the lime. He has the command of a small stream of water, which is conveyed at pleasure into the pit, and in a few days the lime is sufficiently slaked; he then puts the lime and sand, or gravel, into the mill, which not only mixes both together, but incorporates them in a very effectual manner; and, as the lime is sufficiently moist when taken out of the pit, no more water is required for the mortar. If for present use, the quantity he makes at a time is six bushels, as he finds when more is put in, it is apt to strain the cogs, if not made very strong. If the mortar is made with sand alone, the space between the cogs need not be made so wide as three inches. He has a second shaft, with closer cogs, in order to give the mortar another working; the space between these cogs is but two inches; but it does not answer well till after the first shaft has been used, nor is it necessary, unless for very nice work." He adds, that he "made 200 barrels of lime into mortar last summer, and has now the like quantity of lime in the pit for the same purpose. He made six barrels of mortar in a day with ease; a boy of seven years old drives the horse, and the most indifferent one is good enough for the purpose, the draught being so easy." This machine may be wrought by any other power, as water, wind, or steam.

The nature, plan, and construction of the machine are seen at *fig.* 4, in *Plate* XXIV. *Miscellany*, in which A is the plan of

the boarded floor, raised eight inches from the ground, four feet two inches in diameter, and surrounded by a fourteen-inch wall, whose outside height is two feet. B, a sliding door, two feet wide. C, plan of the shaft, with its cogs, or teeth; its length eleven feet eight inches, breadth eight inches, depth five inches. D, plan of the post, or axis, on which the shaft turns round; diameter seven inches, height twenty inches. E E, plan and upright of one of the cogs as it stands in the mill. The plan is a rhombus, the longest diagonal is three inches, the shortest but two, in order to make the angles of the cogs more acute, by which means they will pass through the mortar with the greater ease. F, elevation and section of the mill in perspective.

The inventor states, that the space between the cogs is three inches, except the first to the left of the post, which is but half an inch distant from it, in order to give the cogs to the left a different direction from those on the right; and its use will, by inspection, readily appear. There must be a space of two inches between the end of the cogs and the floor, in order to give the gravel a free passage, which would otherwise strain the cogs, and stop the course of the mill."

Besides the common mortar used in laying of stones, bricks, &c. there are several other kinds: as,

MORTAR. *White*, used in plastering the walls and ceilings; made of ox or cow's hair mixed with lime and water, without any sand. The common method of making this mortar is one bushel of hair to six bushels of lime.

MORTAR *used in making Water-Courses, Cisterns, &c.* is very hard and durable, being made of lime and hogs-grease, sometimes mixed with the juice of figs, and sometimes with liquid pitch; and, after application, is washed over with linseed-oil. See BETON.

For this purpose, mortar made of terras, pozzolana, tile-dust, or cinders, is mixed and prepared in the same manner as common mortar: only that these ingredients are mixed with lime, instead of sand, in a due proportion, which is about half and half. The lime should be made of shells or marble; and in works which are sometimes dry and sometimes wet, instead of terras, which is very dear, tile-dust or cinder-dust may be used.

MORTAR *for Furnaces, &c.* See LUTE.

MORTAR *for Sun-Dials* on walls may be made of lime and sand, tempered with linseed-oil; or, for want of that, with skimmed milk. This will grow to the hardness of a stone.

For buildings, one part of washed soap-ashes, mixed with another of lime and sand, make a very durable mortar. See CÆMENT.

The saltpetre workers in France using the mortar of old buildings for extracting that salt, M. Petit has thought it worthy a peculiar attention, and has made several trials, by way of analysis of mortar, to determine whether it really and essentially contains nitre in it, or whether it be only serviceable in that mixture of salts from which nitre is produced.

The common managers of the saltpetre works are of opinion, that mortar contains in it all the saltpetre they procure from it; and that the wood-ashes, and other substances they use with it, only serve to absorb the fat or oily parts, and to set the saltpetre at liberty to shoot. This they pretend to affirm upon experience; but they do not consider, that though they can procure saltpetre from the rubbish or mortar without the addition of wood-ashes, yet it is not pure mortar that they make their experiments upon, but such as is taken from their own heaps, upon which they always throw all the residuum of their former works, and all that liquor which will shoot no more crystals, but which they call the mother-water of saltpetre.

This gentleman, therefore, very properly judged, that to make a regular trial of the mortar or rubbish alone, he must not take it from their stores, used in the saltpetre works, but pick it himself from the ruins of old buildings.

The mark the saltpetre workers have to know good mortar for their purpose is, that it tastes acrid and salt when applied to the tongue; but to this it may be also added, that it ought to be of a greyish colour, and such as, when powdered and sprinkled upon burning charcoal, yields some sparks of fire; and the more sparks it gives, the better it is for the purpose: and another character of the goodness is, that these well impregnated mortars have a certain unctuosity or fattiness to the touch, which other kinds have not.

The finest of all kinds of mortar for saltpetre work is such as is had from the ruins of old buildings in a low situation, and out of the way of much sunshine; where there has been no great quantity of fire kept, and especially such as has served for the cements of the walls of stables, or the like.

M. Petit chose from such a wall twelve pounds of old mortar: this he had beaten to powder, and poured upon it eighteen pints of water; the whole was then set over the fire, and stirred from time to time for three or four hours, that the water might be well tinctured from the mortar; after this the water was filtered through paper, and was then found to be tinctured to a pale, yellow, transparent bitter, and somewhat acrid to the taste.

The impregnation may be made without heat, by only stirring the mortar about for nine or ten days in cold water, and a quantity of the salt taken up will be according to the goodness of the mortar and the quantity of water employed. The common specific gravity of this liquor to water is as 32 to 31, or thereabouts. M. Petit having procured the tincture of fifty pounds of mortar, by several impregnations, in 72 French pints of water, evaporated it so far till it appeared highly charged with saline particles, tasting very acrid and bitter, and being of a brownish-red colour; and its specific gravity was in this state to water as 4 to 3, there being more in quantity than about four pints. This was still limpid and of a dusky colour, and was afterwards evaporated over a gentle fire, to the consistence of an extract, which, as it cooled, became much thicker and firmer, resembling butter. This being left open to the air, soon relented into a liquor of the consistence of a syrup: its specific gravity was now to water as 5 to 3; but in leaving it open to the air, it continually attracted fresh humidity, and became less specifically heavy. Experiments made with this extract succeeded in the following manner:

1. It turned the common blue paper to a fine deep red. The impregnations in water uninspissated do this also in different degrees, according to their strength.

2. Mixed in equal quantities with spirit of nitre and with spirit of sea-salt, it made no effervescence or alteration in either.

3. A leaf of gold being put into the mixture of this impregnation with spirit of nitre, was immediately dissolved; and in an hour or two afterwards, the liquor was much clearer than before.

A leaf of gold being put into the mixture of this impregnation and spirit of sea-salt, was in the same manner dissolved in a few minutes. It is generally supposed, indeed, that the spirit of salt alone will dissolve gold; but there seems to be an error in this, founded on the inaccuracy of the preparation of such spirit of salt; for Messrs. Geoffroy and Boulduc

have at different times produced before the French Academy ſpirit of ſalt carefully prepared by themſelves, which would not at all diſſolve gold, not even with the aſſiſtance of heat: even ſuch ſpirit of ſalt would, however, be made to diſſolve gold, by mixing this impregnation with it; ſo that it has the power of diſſolving gold in a great degree.

4. A leaf of ſilver being diſſolved in ſpirit of nitre, and this impregnation of mortar added to the ſolution, the whole became turbid, and a precipitation happened, part of the matter being thrown to the bottom, and part remaining ſuſpended in form of a white cloud, which kept its place without falling.

5. The impregnation being mixed in equal quantities with oil of vitriol formed a coagulum, and made a great efferveſcence, with copious red vapours, and a ſtrong ſmell of aqua fortis; and theſe vapours appeared at any time, on ſtirring the mixture, for ſeveral days together. If a larger quantity of oil of vitriol be added to this coagulum, it all becomes fluid, but ferments violently; and finally, there will be a white matter precipitated to the bottom of the clear liquor; and if a leaf of gold be brought near this mixture, it will be diſſolved even by the vapour which exhales from it. Spirit of nitre has no effect upon this mixture, either in its ſtate of coagulum, or when reduced by more oil of vitriol into a clear liquor; but the volatile ſpirit of urine ferments violently, without the leaſt heat with it.

6. Oil of tartar *per deliquium* being added to the impregnation, the liquors would not readily mix, but remained ſeparate, the impregnation ſinking to the bottom; but on ſtirring them thoroughly together, they finally were made to unite into a white ſubſtance like butter, with a ſtrong urinous ſmell. If a ſmall quantity of corroſive ſublimate be added to this mixture, the urinous ſmell ceaſes; and if oil of vitriol be added, there is a violent fermentation occaſioned; and, in fine, a large quantity of precipitate.

7. This impregnation of mortar being mixed with an equal quantity of a ſolution of corroſive ſublimate, there is nothing remarkable produced, though the mixture be ever ſo much ſhaken; but if a little oil of tartar *per deliquium* be added to this, the mixture becomes turbid, and, on ſtirring all together for ſome time, it becomes white and thick like butter. If to this, more corroſive ſublimate be added in ſolution, it becomes orange-coloured: and, on more ſtirring, this becomes again white; and finally gives a white precipitate at the bottom of a tranſparent liquor.

8. If, inſtead of oil of tartar, an equal quantity of lime-water be added, this in the ſame manner gives an urinous ſmell, and the whole difference is, that the mixture will not become thick with this, as it will with oil of tartar.

9. The impregnation of mortar produced the ſame coagulum in mixing with ſpirit of urine, that it did with oil of tartar *per deliquium*; but it made no coagulation with ſpirit of ſal ammoniac with lime: the occaſion of this difference is, that the ſpirit of urine contains a great deal of volatile ſalt, and the other but little. It is a common error to ſuppoſe that the ſpirit of ſal ammoniac, which is moſt pungent, contains the greateſt quantity of ſalt; but this is not the caſe, for the ſpirit made with lime is much more pungent than that with ſalt of tartar, though the laſt is well known to contain a much larger portion of ſaline particles.

10. If a piece of paper or linen be wetted in this impregnation, and afterwards dried, it takes fire very violently, and ſparkles with the ſame violence as if it was impregnated with ſaltpetre.

From theſe experiments it is abundantly proved, that the impregnation of mortar contains a large quantity of a ſaline and nitrous ammoniac ſalt; for a diſſolution of ſal ammoniac and ſpirit of nitre, mixed together, are found to produce all the changes in the different bodies before named, that the impregnation does. On the whole, though it has been ſuppoſed by Mr. Tournefort, and others, that mortar contained ſaltpetre, ſea-ſalt, and a fixed alkali; yet there does not appear any proof of its containing any of theſe ſalts: no fixed alkali can ever be ſeparated from the impregnation of it; and though the linen or paper, wetted in the impregnation of it, ſparkled when on fire, yet it is not nitre, but merely a nitrous ſal ammoniac, which occaſions that phenomenon. The ſame effect is produced, if the linen or paper be wetted with a mixture of ſpirit of urine and ſpirit of nitre. And the ſeveral experiments before recited prove, that there is in mortar a ſpirit of nitre and a ſpirit of ſea-ſalt, which, with the volatile urinous ſalts, form a nitrous or a ſaline ammoniac. Mem. Acad. Scienc. Par. 1734.

Mortar, in *Chemiſtry*, &c. is an inſtrument very uſeful for the diviſion of bodies, partly by percuſſion, and partly by grinding. They have the form of an inverted bell, and are made of all ſizes and materials, as marble, copper, glaſs, iron, grit-ſtone, and agate. The matter intended to be pounded is to be put into them, and there ſtruck and bruiſed by a long inſtrument called a *peſtle*. This, when large and heavy, ought to be ſuſpended by a cord, or chain, fixed to a moveable pole, placed horizontally above the mortar, which conſiderably relieves the operator, becauſe its elaſticity aſſiſts the raiſing of the peſtle.

Mould

MOULD, or MOLD, in the *Mechanic Arts*, &c. a cavity artfully cut, with defign to give its form, or impreffion, to fome fofter matter applied in it.

Moulds are implements of great ufe in fculpture, foundery, &c.

The workmen employed in melting the mineral or metallic glebe dug out of mines, have each their feveral moulds, to receive the melted metal as it comes out of the furnace; but thefe are different, according to the diverfity of metals and works. In gold mines, they have moulds for ingots; in filver mines, for bars; in copper and lead mines, for pigs or falmons; in tin mines, for pigs and ingots; and in iron mines, for fows, chimney-backs, anvils, cauldrons, pots, and other large utenfils and merchandizes of iron; which are here caft, as it were at firft hand.

MOULDS *of Founders of large Works*, as ftatues, bells, guns, and other brazen works, are of wax, fupported withinfide by what they call a *core*, and covered withoutfide with a cap or cafe. It is in the fpace which the wax took up, which is afterwards melted away to leave it free, that the liquid

metal runs, and the work is formed; being carried thither through a great number of little canals, which cover the whole mould. See FOUNDERY.

MOULDS *of Moneyers* are frames full of fand, in which the plates of metal are caft that are to ferve for the ftriking of fpecies of gold and filver. See COINING.

A fort of concave moulds made of clay, having within them the figures and infcriptions of ancient Roman coins, are found in many parts of England, and fuppofed to have been ufed for the cafting of money.

Mr. Baker having been favoured with a fight of fome of thefe moulds found in Shropfhire, bearing the fame types and infcriptions with fome of the Roman coins, gave an account of them to the Royal Society.

They were found in digging of fand, at a place called Ryton, in Shropfhire, about a mile from the great Watling-ftreet road. They are all of the fize of the Roman denarius, and of a little more than the thicknefs of a halfpenny. They are made of a fmooth pot or brick clay, which feems to have been firft well cleanfed from dirt and fand, and well beat or kneaded, to render it fit for taking a fair impreffion. There were a great many of them found together, and there are many of them not unfrequently found in Yorkfhire; but they do not feem to have been met with in any other kingdom, except that fome have been faid to be once found at Lyons. They have been fometimes found in great numbers, joined together fide by fide, on one flat piece of clay, as if intended for the cafting a great number of coins at once; and both thefe, and all the others that have been found, feem to have been of the emperor Severus. They are fometimes found impreffed on both fides; and fome have the head of Severus on one fide, and fome well-known reverfe of his on the other. They feem plainly to have been intended for the coinage of money, though it is not eafy to fay in what manner they can have been employed to that purpofe, efpecially thofe which have impreffions on both fides, unlefs it may be fuppofed that they coined two pieces at the fame time by the help of three moulds, of which this was to be the middle one.

If by difpofing thefe into fome fort of iron frame or cafe, as our letter-founders do the brafs moulds for cafting their types, the melted metal could be eafily poured into them, it would certainly be a very eafy method of coining; as fuch moulds require little time or expence to make, and therefore might be fupplied with new ones as often as they happen to break.

Thefe moulds feem to have been burnt or baked fufficiently to make them hard; but not fo as to render them porous like our bricks, by which they would have loft their fmooth and even furface, which in thefe is plainly fo clofe, that whatever metal fhould be formed in them would have no appearance like the fand-holes by which the counterfeit coins and medals are ufually detected.

MOULDS *of Founders of fmall Works* are like the frames of coiners: it is in thefe frames, which are likewife filled with fand, that their feveral works are fafhioned; into which, when the two frames of which the mould is compofed are rejoined, the melted brafs is run.

MOULDS *of Letter-founders* are partly of fteel and partly wood: the wood, properly fpeaking, ferves only to cover the real mould which is within, and to prevent the workman, who holds it in his hand, from being incommoded by the heat of the melted metal. Only one letter or type can be formed at once in each mould. See *Letter*-FOUNDERY.

MOULDS, in the *Manufacture of Paper*, are little frames compofed of feveral brafs or iron wires, faftened together by another wire ftill finer. Each mould is of the bignefs of the fheet of paper to be made, and has a rim or ledge of wood to which the wires are faftened. Thefe moulds are more ufually called *frames* or *forms*.

MOULDS, *Furnace and Crucible Makers'*, are made of wood, of the fame form with the crucibles; that is, in form of a truncated cone: they have handles of wood to hold and turn them with, when, being covered with the earth, the workman has a mind to round or flatten his veffel.

MOULDS *for Leaden Bullets* are little iron pincers, each of whofe branches terminates in a hemifpherical concave, which, when fhut, form an entire fphere. In the lips or fides, where the branches meet, is a little jet or hole, through which the melted lead is conveyed.

MOULDS, *Laboratory*, are made of wood, for filling and driving all forts of rockets and cartridges, &c.

MOULDS, *Glaziers'*. The glaziers have two kinds of moulds, both ferving to caft their lead: in one they caft the lead into long rods or canes fit to be drawn through the vice, and the grooves formed therein; this they fometimes call *ingot*-mould. In the other they mould thofe little pieces of lead a line thick, and two lines broad, faftened to the iron bars. Thefe may be alfo caft in the vice.

MOULDS, *Goldfmiths'*. The goldfmiths ufe the bones of the cuttle-fifh to make moulds for their fmall works; which they do by preffing the pattern between two bones, and leaving a jet or hole to convey the filver through, after the pattern has been taken out.

MOULD, among *Mafons*, is a piece of hard wood or iron, hollowed withinfide, anfwerable to the contours of the mouldings or cornices, &c. to be formed. This is otherwife called *caliber*.

MOULD, a cavity formed in the external furface of a body, intended to be caft of liquid or foft matter, which after a certain time will acquire folidity.

MOULD, in *Mafonry*, is a templet made to a fection of the ftone intended to be cut. The ends or heading-joints being formed as in a cornice by means of the mould, the intermediate parts are wrought down by ftraight edges or circular templets, according as the work is ftraight or circular, upon the place. When the furface intended to be made is required to be very exact, a reverfe mould is ufed in order to prove the work, by applying the mould in a tranfverfe direction.

MOULDS, among *Plumbers*, are the tables on which they caft their fheets of lead. Thefe they fometimes call fimply *tables*. Befides thefe they have other real moulds, with which they caft pipes without foldering. See each defcribed under PLUMBERY.

MOULDS, among the *Glafs-Grinders*, are wooden frames, on which they make the tubes with which they fit their perfpectives, telefcopes, and other optic machines.

Thefe moulds are cylinders, of a length and diameter according to the ufe they are to be applied to, but always thicker at one end than the other, to facilitate the fliding. The tubes made on thefe moulds are of two kinds; the one fimply of pafteboard and paper; the other of thin leaves of wood joined to the pafteboard. To make thefe tubes to draw out, only the laft or innermoft is formed on the mould; each tube made afterwards ferving as a mould to that which is to go over it, but without taking out the mould from the firft. See GRINDING.

MOULDS ufed in bafket-making are very fimple, confifting ordinarily of a willow or ofier turned or bent into an oval, circle, fquare, or other figure, according to the bafkets, panniers, hampers, and other utenfils intended. On thefe moulds they make, or, more properly, meafure, all their

work: and, accordingly, they have them of all ſizes, ſhapes, &c.

MOULDS, in *Ship Building*, are the ſhapes of the various timbers, knees, &c. made of board from the lines on the mould-loft floor, for the purpoſe of ſawing out the various timbers, &c. to the ſhape required. Alſo thin flexible pieces of pear-tree or box, uſed in drawing the draughts and plans of a ſhip.

MOULD-*Loft* is a long even floor, on which the ſhip is laid-off to its full ſize, from the draughts and ſeveral other operations, which will be correctly explained in the article SHIP-BUILDING.

MOULDS, among *Tallow Chandlers*, are of two kinds: the firſt for the common dipped candles, being the veſſel in which the melted tallow is diſpoſed, and the wick dipped.

This is of wood, of a triangular form, and ſupported on one of its angles, ſo that it has an opening of near a foot at top: the other, uſed in the fabric of mould candles, is of braſs, pewter, or tin. Here each candle has its ſeveral mould. See each under CANDLE.

MOULD, among *Gold Beaters*, a certain number of leaves of vellum, or pieces of guts, cut ſquare, of a certain ſize, and laid over one another, between which they put the leaves of gold and ſilver which they beat on the marble with the hammer. See GOLD-*Leaf*.

They have four kinds of moulds; two of which are of vellum, and two of gut: the ſmalleſt of thoſe of vellum conſiſts of forty or fifty leaves; the largeſt contains a hundred: for the others, each contain five hundred leaves.

The moulds have all their ſeveral caſes, conſiſting of two pieces of parchment, ſerving to keep the leaves of the mould in their place, and prevent their being diſordered in beating.

Muffle

MUFFLE, in *Metallurgy*, is an arched cover, refifting the ftrongeft fire, and made to be placed over copels and tefts in the operation of affaying, to preferve them from the falling of coals or afhes into them; though at the fame time of fuch a form, as not to hinder the action of the air and fire on the metal, nor prevent the infpection of the affayer.

The muffles may be made of any form, fo that they have thefe conditions; but thofe ufed with copels are commonly made femi-cylindrical, or when greater veffels are employed, in form of a hollow hemifphere.

The muffle muft have apertures, that the affayer may look in, and the fore-part of it muft always be quite open, that the air may act better in conjunction with the fire, and be inceffantly renewed; for without this, fcarcely any fumes are to be produced, and without thefe, the vitrification of lead is fcarcely practicable; for when the air is once filled with a certain quantity of vapours, it fcarcely admits any more afterwards; and for this reafon a conftant fucceffion of frefh air is neceffary. The apertures in the muffle ferve alfo for the regimen of the fire; for the cold air rufhing into the larger opening before, cools the bodies in the veffel; but if fome coals are put in it and its aperture before be then fhut with a door fixed to it, the fire will be increafed to the higheft degree, much more quickly than it can be by the breathing-holes of the furnace. Another ufe of thefe apertures is alfo, that the arfenical vapours of lead and antimony, paffing through the holes in the back part of the muffle, may not be offenfive to the affayer, who ftands before it.

As to the height, length, and depth of the muffles, thefe muft be proportioned to the fize and number of the veffels they are intended to cover; and care muft be taken in this, that all parts of the inner furface of thofe veffels muft be within the reach of the affayer's eye. The moft frequent fize of the muffle, however, is four inches high, fix or eight inches long, and four or fix inches broad. The fegments cut off at the bafes, for the leffer holes, muft be of fuch a proportioned height, that the leaft veffels put under it, may not be in the way of coals or afhes falling into them, for that always hinders the vitrification of lead, and the deftruction of the other metals and femi-metals, and will fometimes entirely reduce them again when already deftroyed; and the fcoriæ, foftened by afhes, foften and retard the operation.

Wooden moulds of a proper fhape are moft convenient for the making of thefe muffles, and the matter of which they are made is the fame with that of the German clay-tefts; this is, either a pure native clay, of a condition to bear the fire, which will be known upon the trial; or fuch clay hardened by a mixture of the powder of ftones: and in order to the forming of thefe, the mafs muft be made tolerably foft and pliant. Knead a fufficient quantity of this mafs with your hands upon a flat ftone; fpread it out evenly into a thin cake or plate, fomewhat longer and broader than you intend the muffle to be made; and fo thick, that two or more thin plates or lamina, of about two lines thick each, may be cut off from it. This is eafily done by rolling the mafs on the ftone with a rolling-pin, ftrewed over lightly with afhes, or powder of chalk.

When the cake is thus rolled out, with a thin, fine, and perfectly ftraight brafs-wire, cut off from the cake one thin plate; this muft be done with great caution left it fhould break: take this up, and rubbing it over with oil or fat, lay it over the mould; then cut out a femicircular piece from the mafs, of the fame thicknefs with the former, and with this cover the back plane, or farther end of the mould, joining the edges of this plate to thofe of the former, clofely and perfectly, by wetting them well with water.

Next cut off from the cake another thin plate, to be the bottom of the muffle; this may be either left loofe for the muffle to be placed on it occafionally, or the bottom edges of the already formed muffle may be joined to it all round by means of water, as the back was before jointed to the arched part of the muffle. But whether it be intended that the bottom fhould be thus fixed on, or left loofe, it muft

be half an inch broader every way than the bottom of the muffle, that this may ſtand the more ſure and firm upon its baſis.

When the muffle is thus made, wet your hand, and rub it carefully all over, that the ſmall, and perhaps inviſible, cracks and chinks in the plates may be cloſely joined, and the whole matter of it applied perfectly cloſe to the ſurface of the mould.

When the muffle has been ſome time expoſed to the air, and is ſomewhat dried, and hardened on the mould, cut out two or three hemiſpherical pieces on each ſide, to make the holes before deſcribed, at the baſis and back, and then draw away the mould from within it; for if the muffle is ſuffered to dry perfectly on the mould, it always cracks. When the whole is perfectly dry, let it be baked in a potter's kiln, or in the aſſayer's oven; but without great care in the latter method, and lighting the fire at top at firſt, it is apt to crack; ſo that the potter's kiln, where at hand, is much the better way of baking it.

If there be adapted to the formerly deſcribed convex mould, another concave one nearly fitting it, only leaving room for the thickneſs of the muffle between them, and the clay be placed between them, and formed by this means into its exact ſhape, by a ſtrong and every way equal preſſure, this will make muffles not only with much leſs trouble, but they will be much ſtronger, leſs apt to crack, and more capable of reſiſting the fire, than thoſe made by the hand in the other way.

The only cautions neceſſary for making theſe, are, that the clay be a little drier than when it is to be worked by the hand; that the ſides, both of the inner and convex mould, and of the outer concave one, be thoroughly oiled or greaſed, and the preſſure on the ſurface of the outer or concave mould be as ſtrong and equal as may be. There is no clay better for making theſe muffles than the Windſor-loam, an earth well known among the chemiſts and glaſſmen, and always to be ſold in London; and rubbing the inſide of the mould with black lead in fine powder very well ſupplies the place of greaſing them, to prevent the matter from ſticking to them.

Theſe are the muffles ordinarily uſed in aſſaying; but when very large teſts are to be covered, they uſe large ſpheroidal muffles, made of caſt iron, or ſometimes of the ſame clay, and wrought in the ſame manner, only made upon proportionably larger moulds. The clay is uſually, for theſe large ones, only laid in a lump on the top of the mould, and with wet hands ſpread all over it to the bottom, and by this means a muffle is made with little trouble. Cramer.

Nails

NAILS, in *Building*, &c. are little metalline members, ſerving to bind or faſten the parts together, &c.

The ſeveral kinds of nails are very numerous. As *back* nails, made with flat ſhanks to hold faſt, and not open the wood. *Clamp* nails, thoſe proper to faſten the clamps in buildings, &c. *Claſp* nails, whoſe heads are flatted, and claſping and ſticking into the wood, render the work ſmooth, ſo as to admit a plane over it: the moſt common in building are diſtinguiſhed by 10*d*., 20*d*., 2*s*., &c. *Clench* nails, thoſe uſed by boat, barge, &c. builders, with boves or nuts, and often without: for fine work, they are made with claſp heads, or with the head beat flat on two ſides. *Clout* nails, thoſe ordinarily uſed for nailing on of clouts to axle-trees; they are flat-headed nails, and iron work is uſually fixed with theſe nails. *Deck* nails, thoſe proper for faſtening of decks in ſhips, doubling of ſhipping, and floors laid with planks. *Dog* nails, or *j bent* nails, proper for faſtening of hinges to doors, &c. *Flat* points are of two kinds, *viz.* *long*, much uſed in ſhipping, and proper where there is occaſion to draw and hold faſt, yet no neceſſity of clenching; and *ſhort*, which are fortified with points, to drive into oak, or other hard wood. *Lead* nails, uſed to nail lead, leather, and canvas, to hard wood: theſe are *clout* nails dipped in lead or ſolder. *Port* nails, commonly uſed to nail hinges to the ports of ſhips. *Ribbing* nails, uſed to faſten the ribbing, to keep the ribs of ſhips in their place in building. *Roſe* nails are drawn four-ſquare in the ſhank, and commonly in a round tool. *Rother* nails, chiefly uſed to faſten rother-irons to ſhips. *Scupper* nails, much uſed to faſten leather and canvas to wood. *Sharp* nails, much uſed, eſpecially in the Weſt Indies, made with ſharp points and flat ſhanks. *Sheathing* nails, uſed to faſten ſheathing-boards to ſhips: the rule for their length is, to have them full three times as long as the board is thick. *Square* nails, of the ſame ſhape as *ſharp* nails; chiefly uſed for hard woods. *Brads*, long and ſlender, without heads, chiefly uſed for thin deal work, to prevent ſplitting. To which may be added *tacks*; the ſmalleſt ſerving to faſten paper to wood; middling, for wool-cards and oars; and larger, for upholſterers and pumps. They are diſtinguiſhed by the names of white *tacks*, 2*d*., 3*d*., and 4*d*. *tacks*.

Nails are ſaid to be toughened, when too brittle, by heating them in a fire-ſhovel, and putting ſome tallow or greaſe among them.

Nails are ſold ſix-ſcore to the hundred.

NAILS, *Manufacture of*. The immenſe conſumption of theſe articles, in all the mechanic arts and trades, cauſe their fabrication to be a conſiderable branch of national manufacture. It is chiefly carried on in Staffordſhire, in the neighbourhood of Dudley, Wolverhampton, and Birmingham: indeed it is the principal conſumption of the malleable iron made in that part of England. The iron uſed in the nail trade is of the cheapeſt ſort, chiefly made in the Pudling furnaces, and worked by rollers inſtead of a forge-hammer. (See IRON.) This metal is, by repeated rolling, reduced into ſmall thin bars, which are then paſſed through the grooves of the ſlitting-rollers, and thus divided or ſlit into three, four, five, or ſix ſmall ſquare rods, of a proper ſize to make nails. (See ROLLING-*Mill*.) Theſe, which are called nail rods, are a very extenſive article of trade. The nailers reſide chiefly in the cottages, where the women and children aſſiſt in the labour. They employ forges ſuch as are uſed by ſmiths; but the bellows are very lightly loaded, ſo that a very ſmall motion given to them now and then will blow ſufficiently to heat the rods; two, three, or four of which, according to their ſize, are always kept in the fire together: and when any one has a good red heat, the nailer takes it out of the fire, and, battering it on the anvil, brings it to a ſharp ſquare point at two or four ſtrokes; he then applies it over the edge of a chiſel, fixed on the anvil, and by ſtriking a ſingle blow on the rod, cuts off a ſufficient length to make a nail, which falls into a tin pan; then he makes another, and cutting it off likewiſe, returns the end of the rod to the fire for another heat: now, with a pair of tweezers, like ſugar-tongs, he takes up the nail, and introduces its point into a ſquare tapering hole, made acroſs through the end of an iron tool or mould; by ſtriking a blow or two on the end of the iron, he flattens it down, and forms a head, the figure of which is determined by the number and direction of the blows given it. This proceſs is conducted with a ſurpriſing rapidity, as the nailers, by long practice, acquire a mechanical habit of forming a complete nail by a certain number of ſtrokes, ſo as never in the courſe of an hour to make an unneceſſary movement. For large nails they can only make one, and cut it off, at each time they take the iron from the fire; becauſe they would be un-

able to get the heading finiſhed, whilſt they were ſufficiently hot. The length of the nail is regulated by a ſtop, fixed at a certain diſtance from the edge of the chiſſel, ſo that the point of the nail being applied to this, determines the proper place for the edge of the chiſſel. The ſize of the mould withinſide, and the dimenſions to which the point of the nail is reduced by hammering, cauſes the cut end to project above the ſurface of the mould more or leſs; ſo that the head will be thicker or thinner, and have its quantity of metal regulated, by the degree of taper given to the point: therefore, the art of the workman is diſplayed in ſtriking with a due force, ſo that every nail ſhall be made of the ſame ſize, by a certain number of blows. In this manner the great number of all nails are made; but the great expence of labour has induced many manufacturers to turn their attention to inventions which would diminiſh the labour, ſo as to enable them to bring their nails to the market at reduced prices, or of a better quality. Many patents have been taken out for theſe inventions, ſome of which we ſhall briefly notice.

Mr. W. Finch of Wimboorne, in Staffordſhire, obtained a patent in 1790, for manufacturing nails by machinery. He propoſed, by means of a water or ſteam-mill giving motion to a main ſhaft or axis, to actuate a number of ſmall hammers, to work either in a tilt or lift manner. By theſe hammers the nails were to be forged; but the operation was to be divided among three people for headed nails: thus, one to attend the fire, and carry the rods, as faſt as they were properly heated, to the ſecond perſon, ſtationed before the hammer, who would make the nails in the moſt expeditious manner, by only turning the rod about under the hammer; when cut off, they were taken by the third perſon, who finiſhed the heads in a tool as above deſcribed, but by means of a hammer worked by machinery, inſtead of hard labour. By theſe contrivances, in conſequence of the more ſpeedy motion of the machine hammers, ſeveral nails were to be made at once heating of the rod; whereas by the old method, only one, or two at moſt, could be made; thus making a great ſaving of labour: and as the operation required no ſtrength, children might eaſily make the largeſt ſpikes; the motion of the hammer being ſo regular, that they could eaſily acquire a dexterity in turning the rods properly to receive the blows.

In the year 1790, Mr. Thomas Clifford, of the city of Briſtol, obtained two patents for the manufacture of nails of every kind. The principle on which his firſt invention was founded, was that of making the nails in a die, that is, by having a die, or the impreſſion of the nails to be cut, formed in one or more pieces of ſteel; and the iron, of which the nails are to be formed, is drawn or rolled into the proper form or thickneſs, and, by a force adapted to the purpoſe, preſſed into a cavity or die, ſo as to form the nails either complete, or ſo nearly complete, as that they can be finiſhed with very little labour. This operation may be done in ſeveral ways, but the one particularly recommended by Mr. Clifford is by rollers of iron or ſteel, and worked either by water, ſteam, wind, horſes, &c.

The two rollers are to be made of iron, and caſed with ſteel, each of the ſame diameter, which is proportioned to the length and ſize of the nail intended to be made. Each roller ſhould have a cog-wheel on it, the cogs of one roller to work into thoſe of the other, ſo that both the rollers may perform the ſame exact revolution. One half the impreſs of the nail is to be cut in the ſurface of one roller, the other half in the other, ſo that the two impreſſions form a cavity or die of the exact form of a nail, extending the lengthways of the nail on the circumference of the rollers; and as many impreſſions of the ſame kind may be cut in the rollers, one at the end of the other, as will complete their circumference, and continue the cavity all round the rollers; the point of one nail joining the head of the next, or the two points and two heads joining each other. The rollers muſt, in this as in other caſes, be made to work very true and cloſe to each other.

The mode of operation is this: a rod of iron, previouſly rolled or drawn to a convenient ſize, is to be heated, and, while hot, the end of it is put between the rollers into the cavity or die which forms the impreſſion of the nail. The rollers, being now put in motion, will draw the iron through, and preſſing it into the cavities or dies, forms the iron into nails, one joined to the other, which muſt afterwards be ſeparated, by means of inſtruments acting as nippers, ſhears, chiſſels, &c. The rollers, being made to work very cloſe to each other where the edge of the nail is formed, will prevent much of the metal from being preſſed out on each ſide of the nail, and what is preſſed out may be cut off by inſtruments adapted to the purpoſe. Several pairs of rollers may be made to work together, and each pair may have ſeveral rows of dies cut on them, ſo as to form the impreſſion for ſeveral ſtrings of nails; and a rod of iron being put into each of them, will roll out as many ſtrings of nails with one revolution of the rollers. A pair of rollers may alſo have the greater part of their ſurface cut with dies, and a flat bed made to paſs between the rollers ſo as to form ſheet nails; all of them connected to one another by thin plates of the iron of which they are compoſed; and this would require each nail to be cut out, or ſeparated from the ſheet by proper inſtruments.

Mr. Clifford's ſecond invention conſiſts, 1ſt, in drawing the iron or other metal into a tapering or wedge-like form, according to the length and thickneſs of the different ſizes of nails to be made. 2dly. The nails are to be cut out of thoſe wedge-like or tapering plates by means of a punch, the face of which is made according to the ſize, taper, and form of the nail to be cut out; as alſo having a hollow bolſter, the hollow or aperture of which muſt alſo be made of the ſize and form of a nail, and conſequently to fit and receive the punch above-mentioned. The punch, thus fitted to the bed, and ſliding in a proper frame to keep it ſteady, will, by a blow, or by preſſure, cut or force part of the taper plate into and through the aperture of the bed fitting to it, and by which the nail is formed. This operation is by the manufacturers of buckles, buttons, &c. called cutting out. 3dly. To form the heads of horſe nails called roſe heads, and others of nearly a ſimilar kind: after the operations of drawing and cutting out, the nail is to be put into a heading tool, alſo called a bed, which bed receives the nail, excepting a ſmall portion at the thick end, out of which the head is formed by a punch or die. This die, by blow or preſſure, forms the head as required, and when the nails are made of hard iron, after they are cut in the way deſcribed, the thick end is made hot before they are put into the bed, or heading tool. 4thly. Another method adopted in the manufacture of nails is, by cutting them out of or from plates of equal thickneſs, and afterwards to point them either by hammer or other preſſure. 5thly. In making nails that are of a triangular form, the plate or ſtrip of iron is preſſed or ſtamped into a die, having impreſſions cut to the form of ſuch nails, after which they are cut out by a punch.

About 15 years ago, a very extenſive trade was eſtabliſhed in Birmingham and Sheffield of cut brads: that kind of nails called brads having no head, or at leaſt only a ſmall projecting leaf on one ſide, was eaſily cut out by machinery, without the trouble of forging, but latterly the method has been

improved, so far as to produce all kinds of small nails. The iron is rolled out to large thin sheets, of the proper thickness to form a nail; this is cut up by strong shears into parallel slips or ribbands, the width of them being equal to the length of the intended nails, which are cut off, one at a time, from the end of the slip: the cutting line is not exactly perpendicular to the length of the piece, but rather inclined, so as to make the nail, which is cut off sharp at one end; the next time the cutting line is inclined the other way, so that the head of one nail is cut from the same edge of the slip as the point of the next, and so on alternately. The cutting is performed by the *Fly-press* (see that article), proper dies or cutters being applied in it: the lower or fixed die consists of a cutter or bar of steel set up edgeways, and one of the angles of its upper side is ground to a sharp straight edge. The slider of the press carries a die, consisting of a square bar of steel moving perpendicularly by the action of the screw, and when it is forced down, one of its flat sides applies exactly against the straight edge of the fixed cutter above-mentioned; but when the moving cutter is raised up to the highest, a part is observed, where its flat side is cut away, in such a manner as to leave a considerable space between its face and the edge of the fixed cutter at one end of the edge, but touching it at the other. By this means, when the end of a slip of iron is pressed against the face of the moving cutter in its reduced part, a short piece of the end of the slip will project over the edge of the fixed cutter, and the moving cutter being forced down by the screw of the press, the shoulder of the part which is cut away comes down upon the end of the slip, cutting it off to the line of the edge of the fixed cutter, and therefore removing a small piece from the end, which being of a proper breadth at one end, and regularly tapered away to nothing at the other, makes a very good brad. The circumstance of its being parallel in the other direction, is the great recommendation to this kind of nail, because it will drive without first making any hole in the wood and does not split: the point of a nail of this kind is like the edge of a chissel, and the length of this edge being set across the grain of the wood, when driven down it cuts through, and divides all the fibres of the wood it meets with, and by turning the divided ends of them down, as it is driven deeper, their elasticity binds the nail forcibly between them, so that this nail will hold in the wood faster than any other kind, but being parallel in the other direction, does not tend to open or split the wood in the direction of the grain.

In cutting brads by this method, the workman or woman is seated before the press, which is the same as is shewn in *fig.* 1. *Plate* XXVII. *Mechanics*, holding the handle, *a*, of its fly in the right hand, and the slip of iron in the left: by pushing the handle back, the moving cutter is raised up, and the end of the slip is pressed up to the cutter: then by drawing forwards the handle, the cutter is pressed down, carrying with it a nail, as before mentioned: the handle is then pushed back to cut another, but the slip of iron or bar must first be turned over, to bring the other side upwards: by this means, the bar will at the second time be cut with an inclination in an opposite direction to what it was the first time, so that the head of one nail will come from the same side of the bar as the point of the last, and this alternately of the whole. A woman will, by this method, cut small nails at the rate of 40 or 50 *per* minute, and if they are intended for brads, they have a small leaf left at one side of the head in cutting, by a particular shape of the dies.

For nails which require heading, the pieces or nails, cut as before mentioned, are taken to another woman, who fixes them one at a time in a vice, over which a heavy hammer is placed, being fitted on an axis, that it may rise and fall with precision upon the head of the nail in the vice; its weight is suspended by a wooden spring pole, and the woman, when she has fixed the nail, raises the head of the hammer a little, and then brings it sharply down on the nail, so as to head it at one blow. The shape of the head is determined by an indention made in the face of the hammer, and its thickness depends upon the quantity which is left sticking out above the chaps of the vice.

Messrs. Wilmore and Tonk obtained a patent, in 1808, for a method of cutting nails, which they have thus described.

They take a nail rod, of a size suitable to that of the nail intended to be manufactured, and applying it to a common screw-press, mounted with proper cutters, cut off from the end of the rod two pieces at once, obliquely across the rod in one place, and directly across it in another. Two studs or tops are set up, which are attached to the press, and are moveable in the direction of the rod, for the purpose of ascertaining the length of the nail; and both studs are adjustable in the cross direction of the rod, so that the obliquity of the cut, according to the kind of nail to be made, is thereby determined, as well as the length of the nail. This is called the first operation.

The second operation is to anneal the pieces so cut off, if the iron should not be sufficiently malleable, which is done in the usual and well-known manner. The third operation is that of heading, which, for clasp head nails, consists of two parts, one for gathering, and the other for forming the head of the nail. The first part of this operation is performed by putting a piece, cut off the rod of iron as before described, into a pair of clams, leaving as much of the thick end projecting above the clams as is sufficient to form the head. These clams have steel bits let into them with sharp edges, which press only against the two opposite sides of the piece, and which have the effect of two chissels, when the punch of the press is brought down upon the piece with considerable force, and raise or gather up iron towards forming the head. The second part of this operation is to put the nail, thus prepared, into another pair of clams, having bits to correspond to the under side of the head; and the punch, having the impression of the upper side of the head engraved or sunk into it, is brought to press strongly upon the head in the clams, and thereby the clasp head is properly formed.

For nails intended to have rose heads, or any other kind of heads, except clasp heads, the first part of this heading operation is not absolutely necessary, but the bits which for clasp nails must have sharp edges, must for the other nails have blunt edges, to prevent the under-cutting. For the second part of this operation, the piece is put either into a pair of clams, or into the tool commonly called a bore, and then pressed with punches properly engraved, or sunk, according to the kind of head wanted. By the first of all these operations, the piece cut off the rod of iron is formed something like a mortise chissel. The fourth operation is to point it, which is done by putting the piece into a bed of steel, in which is cut a nick or groove having parallel sides, but the bottom rising towards the end, where the nail is to be formed; the end of the punch, which presses upon the point of the nail, is made to project more than the other part, so as to meet the corresponding part of the bed, when the punch is brought upon the nail. The groove or nick in the bed should be just wide enough to receive the nail easily, but prevent it from twisting when the impression is made. The nail is put twice into the nick, once within the chissel, from the end lying horizontal, and next turning a quarter round to press the chissel edge into a pointed form. If the nails, by the strong pressure which is necessary in this opera-

tion, ſhould become too hard to clench, they are to be annealed in the uſual way, which may be called the fifth operation. The third, fourth, and fifth operations, above deſcribed, are applied to nails, or pieces cut off from ſheet or rolled iron in the ordinary way; but as, in conſequence of the fifth operation, which is neceſſary to give them the quality of clenching, they are apt to be too ſoft to drive well, a ſixth operation is applied, *viz.* quenching them in water when red-hot, which gives them ſtiffneſs enough to drive without rendering them too brittle to clench.

The Americans appear to have carried the invention of cutting nails by machinery to a greater perfection than has been done in this country. From ſome letters, publiſhed in 1810, by the American ſecretary to the treaſury, in his report on the manufactures of that country, it appears that they have invented machines which perform the cutting and heading at one operation, and with ſuch a rapidity, that one machine will furniſh upwards of one hundred nails *per* minute: he ſays, "the importance of nail machinery in Maſſachuſetts, and of all that relates to rolling and ſlitting-mills, with which nail machinery is immediately connected, requires that a particular account ſhould be given of them. In old countries nails are forged, here they are cut, and it is curious to trace the progreſs of American genius through the various ſteps of this invention. Twenty years ago ſome men, now unknown, and then in obſcurity, began by cutting ſlices out of old hoops, and by a common vice, griping theſe pieces, headed them with ſeveral ſtrokes of the hammer: by progreſſive improvements ſlitting-mills were built, and the ſhears and the heading tools were perfected, yet much labour and expence were requiſite to make nails. In a little time, Jacob Perkins, Jonathan Ellis, and a few others, put into execution the thought of cutting and of heading nails by water, but being more intent upon their machinery than upon their pecuniary affairs, they were unable to proſecute the buſineſs. At different times other men have ſpent fortunes in improvements, and it may be ſaid with truth, that more than a million of dollars have been expended; but at length theſe joint efforts are crowned with complete ſucceſs, and we are now able to manufacture at about one-third of the expence that wrought nails can be manufactured for, and nails which are ſuperior to them; for at leaſt three-fourths of the purpoſes to which nails are applied, and for moſt of thoſe purpoſes, they are full as good. The machines made uſe of by Odiorne, thoſe lately invented by Jonathan Ellis, and a few others, preſent very fine ſpecimens of American genius.

"To northern carpenters it is well known, that in almoſt all inſtances it is unneceſſary to bore a hole before driving a cut nail; all that is requiſite is, to place the cutting edge of the nail acroſs the grain of the wood: it is alſo true, that cut nails will hold better in the wood. Theſe qualities are, in ſome rough building works, worth twenty *per cent.* of the value of the article, which is equal to the whole expence of manufacturing. For ſheathing and drawing, cut nails are full as good as wrought nails: only in one reſpect are the beſt wrought nails a little ſuperior to cut nails, and that is where it is neceſſary they ſhould be clenched. The manufacture of cut nails was born in our country, and has, within its boſom, advanced through all the various ſtages of infancy to manhood; and, no doubt, we ſhall ſoon be able, by receiving proper encouragement, to render them ſuperior to wrought nails in every particular.

"The principal buſineſs of rolling and ſlitting-mills is, rolling nail plates; they alſo ſerve to make nail rods, hoops' tires, ſheet iron, and ſheet copper: in this State we have not leſs than twelve."

"Theſe mills could roll and ſlit 7000 tons of iron a-year: they now, it is preſumed, roll and ſlit each year about 3500 tons, 2400 tons of which, probably, are cut up into nails and brads, of ſuch a quality, that they are good ſubſtitutes for hammered nails, and, in fact, have the preference with moſt people for the following reaſons, *viz.* on account of the ſharp corner and true taper with which cut nails are formed; they may be driven into harder wood, without bending or breaking, or hazard of ſplitting the wood, by which the labour of boring is ſaved, the nail, one way, being of the ſame breadth or thickneſs from head to point." We are informed that J. C. Dyer, eſq. who has had the American machinery communicated to him, to be introduced into this country, has lately taken out patents in Great Britain, with a view of eſtabliſhing the trade in this country.

Nealing

NEALING, or ANNEALING, in the arts, confifts in making metals red-hot, which have become hard and brittle by working, in order to reftore their former malleability and tractability. All metals have the property of becoming more or lefs hard and unmalleable, after undergoing the operation of the hammer. Metals thus affected are more elaftic than they were before, but, at the fame time, they become more brittle. They are the more fenfibly affected in this manner in proportion as the metals are naturally harder. Copper is fo much affected, and even gold and filver, by hammering and compreffion, that they foon ceafe to be malleable, and inftead of being extended under the hammer they crack and fplit. Hence the neceffity of annealing the common coins of the country, to which we have referred under the article MINT. In all cafes the labour of hammering, when it is to be long continued, muft occafionally be interrupted to foften and reftore malleability to metals; this is effected by making them red-hot, and fuffering them to cool gradually. Thus heat produces the fame effect on metals, in the ftate defcribed, as it does upon tempered fteel, for, if the hardeft tempered fteel be made red-hot and cooled flowly, it becomes as tractable and ductile as the fofteft iron. Articles of glafs are alfo nealed before they are fit for ufe, by placing them in a furnace, and after they have been raifed to a due degree of temperature, they are fuffered to cool gradually. Without this operation glafs veffels would be entirely ufelefs, as they would not admit of the leaft change of temperature from cold to heat, nor would they bear the flighteft blow. See GLASS.

NEALING *of Glafs* is the baking of glafs, to dry, harden, and give it the due confiftence, after it has been blown, and fafhioned into the proper works.

This is ufually performed in a kind of tower, called the *leer*, built over the melting furnace. See GLASS.

NEALING *of Glafs* is alfo ufed for the art of ftaining of glafs with metalline colours.

One fine ufe of filver, fays Mr. Boyle, was only difcovered fince the art of annealing upon glafs came to be practifed. For prepared filver, or even the crude metal, being burnt on a glafs plate, will tinge it of a fine yellow, or golden colour. And there are feveral mineral earths, and other coarfe matters, of ufe in this art, which by means of fire impart tranfparent colours to glafs, and fometimes very different ones from thofe of the bodies themfelves.

NEALING *of Steel*, is the heating it in the fire to a blood-red heat; and then taking it out, and letting it cool gently of itfelf.

This is done to make it fofter, in order to engrave or punch upon it. See TEMPERING, and ENGRAVING. See alfo STEEL.

NEALING is alfo ufed for the art or act of burning or baking earthen or other ware in an oven.

The miners at Mendip, when they meet with a rock they cannot cut through, anneal it, by laying on wood and coal, and contriving the fire fo that they quit the mine before the operation begins, it being dangerous to enter it again before it be quite cleared of the fmoke. Phil. Tranf. N° 39. p. 769.

NEALING *of Tile* is ufed in ancient ftatutes for the burning of tile.

The word is formed of the Saxon *onælan*, *accendere*, *to light*, *burn*.

Needle

NEEDLE, a very common little inſtrument, or utenſil, made of ſteel, pointed at one end, and pierced at the other; uſed in ſewing, embroidery, tapeſtry-work, &c.

Needles make a very conſiderable article in commerce; and the conſumption of them is almoſt incredible. The ſizes are from N° 1, the largeſt, to N° 25, the ſmalleſt. There is ſcarcely any commodity cheaper than needles; which will appear ſomething extraordinary to the reader, after he has been ſhewn the great number of operations they undergo, before they are brought to perfection.

NEEDLES, *Manufacture of.* German and Hungarian ſteel is of moſt repute for needles. The firſt thing is to paſs it through a coal fire, and under a hammer, and to bring it out of its ſquare figure into a cylindrical one: this done, it is drawn through a large hole of a wire-drawing iron, returned into the fire, and drawn through a ſecond hole of the iron, ſmaller than the firſt; and thus ſucceſſively from hole to hole, till it has acquired the degree of fineneſs required for that ſpecies of needles; obſerving every time it is to be drawn, that it be greaſed over with lard to render it the more manageable. The ſteel, thus reduced into a fine wire, is cut in pieces of the length of the needles intended. Theſe pieces are flattened at one end, on the anvil, in order to form the head and eye: they are then put into the fire, to ſoften them farther; and thence taken out and pierced at each extreme of the flat part, on the anvil, by the force of a puncheon of well tempered ſteel, and laid on a leaden block, to bring out, with another puncheon, the little piece of ſteel remaining in the eye.

The corners are then filed off the ſquare of the heads, and a little cavity filed on each ſide the flat of the head. This done, the point is formed with a file; and the whole filed over.

They are then laid to heat red-hot, on a long, flat, narrow iron, crooked at one end, in a charcoal fire; and, when taken out thence, are thrown into a baſon of cold water to harden. On this operation a good deal depends; too much heat burns them, and too little leaves them ſoft; the medium is only to be learnt by experience.

When they are thus hardened, they are laid in an iron ſhovel, on a fire, more or leſs briſk, in proportion to the thickneſs of the needles; taking care to move them from time to time. This ſerves to temper them, and take off their brittleneſs; great care, here too, muſt be taken of the degree of heat. They are then ſtraightened, one after another, with the hammer; the coldneſs of the water, uſed in hardening them, having twiſted the greateſt part of them.

The next proceſs is the poliſhing. To do this, they take twelve or fifteen thouſand needles, and range them in little heaps againſt each other, on a piece of new buckram, ſprinkled with emery duſt. The needles, thus diſpoſed, emery-duſt is thrown over them, which is again ſprinkled with oil of olives: at laſt, the whole is made up into a roll, well bound at both ends.

The roll is then laid on a poliſhing-table, and over it a thick plank, loaded with ſtones, which two men work backwards and forwards, a day and an half, or two days ſucceſſively; by which means the roll, thus continually agitated by the weight and motion of the plank over it, the needles withinſide, being rubbed againſt each other with oil and emery, are inſenſibly poliſhed.

In Germany, inſtead of hands, they poliſh with water-mills

After poliſhing, they are taken out, and the filth waſhed off them with hot water and ſoap: they are then wiped in hot bran, a little moiſtened, placed with the needles in a round box, ſuſpended in the air by a cord, which is kept ſtirring till the bran and needles be dry.

The needles, thus wiped in two or three different brans, are taken out, and put in wooden veſſels, to have the good

ſeparated from thoſe whoſe points or eyes have been broken, either in poliſhing or wiping: the points are then all turned the ſame way, and ſmoothed with an emery-ſtone, turned with a wheel.

This operation finiſhes them; and there remains nothing but to make them into packets of two hundred and fifty each.

NEEDLES, *Surgeons'*, are generally made crooked, and their points triangular: however, they are of different forms and ſizes, and bear different names, according to the purpoſes they are uſed for.

The largeſt are needles *for amputation;* the next, needles *for wounds;* the fineſt, needles *for ſutures*. They have others, very ſhort and flat, for tendons; others, ſtill ſhorter, and the eye placed in the middle, for tying together of veſſels, &c. Needles for couching cataracts are of various kinds; all of which have a ſmall, broad, and ſharp point or tongue: and ſome with the ſulcus at the point. Surgeons have ſometimes uſed two needles in this operation, one with a ſharp point for perforating the coats of the eye, and another with a more obtuſe point for depreſſing or couching the opaque cryſtalline lens: but care ſhould be taken in the uſe of any of theſe, that they be firſt well poliſhed, with cloth or leather, before they are applied to the eye. See CATARACT and COUCHING.

Mr. Warner obſerves, that the blade of the couching needle ſhould be at leaſt a third part larger than thoſe generally uſed upon this occaſion, as great advantage will be found in the depreſſing of the cataract, by the increaſed breadth of the blade of that inſtrument. The handle, alſo, if made ſomewhat ſhorter than uſual, will enable the operator to perform with greater ſteadineſs than he can do with a larger handled inſtrument.

It is to be obſerved, that needles of ſilver pierce more eaſily in ſtitching arteries after an amputation, than thoſe made of ſteel. Monro, in Med. Eſſ. Edin. vol. v. art. 41.

NEEDLE, *Magnetical*, in *Navigation*, denotes a needle touched with a loadſtone, or ſuſtained on a pivot or centre, on which, playing at liberty, it directs itſelf to certain points in or under the horizon. See MAGNET.

Magnetical needles are of two kinds; *viz. horizontal* and *inclinatory*.

NEEDLES, *Horizontal*, are thoſe equally balanced on each ſide the pivot which ſuſtains them: and which, playing horizontally with their two extremes, point out the north and ſouth points of the horizon. For their application and uſe, ſee COMPASS.

NEEDLE, *Conſtruction of an Horizontal.* A piece of pure ſteel is procured, of a length not exceeding ſix inches, leſt its weight impede its volubility; very thin, to take its verticity the better; and not pierced with any holes, or the like, for ornament ſake, which prevent the equable diffuſion of the magnetic virtue.

A perforation is then made in the middle of its length, and a braſs cap or head ſoldered on, whoſe inner cavity is conical, ſo as to play freely on the ſtyle or pivot, headed with a fine ſteel point.

The north point of the needle, in our hemiſphere, is made a little lighter than the ſouthern, the touch always deſtroying the balance, if well adjuſted before; and rendering the north end heavier than the ſouth, and thus occaſioning the needle to dip.

Now to give the needle its verticity, or directive faculty, it is to be rubbed leiſurely on each pole of a magnet, from the ſouth pole towards the north; firſt beginning with the northern end, and going back at each repeated rub toward the ſouth. A rub in a contrary direction takes away the power communicated by the former.

Compaſs needles may acquire the magnetic virtue by means of magnetic bars in the following manner: lay two needles of equal length, about an inch aſunder, with the north end of one, and the ſouth end of the other pointing the ſame way, and applying two conductors in contact with their ends: then, with two magnetic hard bars, one in each hand, and held as nearly horizontal as can be, with the upper ends, of contrary names, turned outwards to the right and left, let a needle be ſtroked or rubbed from the middle to both ends at the ſame time, for ten or twelve times, a north end of a bar going over the ſouth end of the needle, and the ſouth end of a bar going over the north end of a needle: then, without moving from the place, change hands with the bars, or, in the ſame hands, turn the other ends downwards, and ſtroke the other needle in like manner, and they will both be magnetical: but to make them ſtill ſtronger, repeat the operation three or four times from needle to needle; and at laſt turn the lower ſide of each needle upwards, and repeat the operations of rubbing them, as on the other ſides.

In the rubbings or touchings to procure magnetiſm, the hand ſhould not return directly back the way it came, but ſhould return in a kind of oval figure, carrying the hand about ſix or eight inches beyond the point, where the touch ended; but not beyond, on the ſide where the touch begins.

If, after touching, the needle be out of its equilibrium, ſomething muſt be filed off from the heavier ſide, till it balance evenly. See MAGNET.

The needles that were formerly applied to compaſſes, on board our merchant ſhips, were formed of two pieces of ſteel wire; each of which was bent in the middle, ſo as to make an obtuſe angle; and their ends being applied together made an acute one; ſo that the whole repreſents the form of a lozenge. Dr. Knight, to whom we are indebted for the improvement of the compaſs, found, by repeated experiments, that theſe needles not only varied from the true direction, but from one another, and from themſelves: and he has ſhewn that theſe irregularities were owing to their ſtructure: for the wires of which the needle was compoſed were hardened only at their ends; now if thoſe ends are not equally hard, or if one end be hardened higher up than the other, when they come to be put together, in fixing them to the card, that end which is hardeſt will deſtroy much of the virtue of the other; by which means the hardeſt end will have the greateſt power in directing the card, and conſequently make it vary towards its own direction: and as the wires are diſpoſed in the form of a lozenge, theſe cards can have but little force; ſo that they will often, when drawn aſide, ſtand at the diſtance of ſeveral degrees on either ſide the point from whence they are drawn; for all magnetical bodies receive an additional ſtrength by being placed in the direction of the earth's magnetiſm, and act proportionably with leſs vigour when turned out of it. Therefore, when needles of this kind are drawn aſide from their true point, two of the parallel ſides of the lozenge will conſpire more directly than before with the earth's magnetiſm, and the other two leſs in that direction: by this means the two former ſides will very much impede its return, and the two latter will have that impediment to overcome, as well as the friction, by their own force alone.

The needles formerly uſed on board the men of war, and ſome of the larger trading ſhips, were made of one piece of ſteel, of a ſpring temper, and broad towards the ends, but tapering towards the middle. Every needle of this form is found to have ſix poles inſtead of two; one at each end,

two where it becomes tapering, and two at the hole in the middle. This inconvenience is owing to their ſhape; for the middle part, being very ſlender, has not ſubſtance enough to conduct the magnetic ſtream quite through from one end to the other. In order to avoid theſe inconveniences and errors, the needle, contrived by Dr. Knight for his compaſs, is quite ſtraight and ſquare at the ends, and conſequently has only two poles, although the curves are a little confuſed about the hole in the middle. Needles of this conſtruction, after vibrating a long time, will always point exactly in the ſame direction; and if drawn ever ſo little on one ſide, will return to it again, without any ſenſible difference. Hence Dr. Knight concludes, that a regular parallelopiped is the beſt ſhape for a needle, as well as the ſimpleſt; with the holes for the caps as ſmall as can be well contrived; or if it can be made to anſwer the purpoſe, without any hole at all, it will be ſtill more perfect.—There is a peculiar advantage attending Dr. Knight's needles; for as they are tempered much higher than uſual, they are able to contain a much greater quantity of the magnetic force. See COMPASS.

Mr. Michell ſuggeſts, that it would not be amiſs to cover the needles made uſe of in the ſea-ſervice, with a very thin coat of linſeed oil, or ſome kind of varniſh, that may keep them from ruſting, which is generally reckoned to injure all magnetical bodies that are liable to it. Needles may be touched through ſuch a coat, by applying a great number of bars, if not according to the common method of making magnets. He alſo apprehends, that coated needles may retain a greater degree of magnetiſm, than they otherwiſe would do.

Mr. Michell alſo propoſes to increaſe the weight and length of mariners' needles; and he obſerves, that long needles, properly hung, traverſing to a greater degree of exactneſs than the ſhort ones, may be of conſiderable ſervice on many occaſions: particularly in mines for diſcovering the bearing of one place from another, that they may be able to ſink a ſhaft from above, over any place at pleaſure. In many ſorts of mines, eſpecially thoſe of coal, there are often ſmall quantities of magnetical iron ore, which draw the needle out of its proper direction; now the long needles are leſs liable to be diſturbed by any ſmall things, already magnetical, than ſhorter ones. Michell on Magnets, p. 42, &c.

A needle, on occaſion, may be prepared without touching it on a load-ſtone: for a fine ſteel needle, gently laid on the water, or delicately ſuſpended in the air, will direct itſelf to the north and ſouth.

Thus alſo a needle, heated in the fire, and cooled again in the direction of the meridian, or even only in an erect ſituation, acquires the ſame faculty.

The needle is not found to point preciſely to the north, except in very few places; but deviates from it, more or leſs, in different places, and that too at different times; which deviation is called the *declination*.

New River

NEW RIVER, a moſt important artificial canal, or ſtream of water, paſſing through parts of the counties of Hertford and Middleſex, England, was contrived and principally executed by an individual, ſir Hugh Middleton, in order to ſupply the Britiſh metropolis and its environs with freſh water. That of the Thames, though extremely beneficial to London, was ſo liable to alteration, and ſubject to foulneſs, that a copious ſupply of pure water was extremely deſirable. Beſides, the Thames water muſt be forced to aſcend by machines, even for the lower parts of the city: whereas, a ſtream on the northern ſide of London may be made to flow, in a natural deſcent, to almoſt any quarter of the widely extended metropolis. From theſe conſiderations, in the reign of James I., Hugh Middleton, citizen and goldſmith, projected the plan of bringing water out of Hertfordſhire, in a channel to London. Meeting with no cooperation, he, at length, in the year 1608, commenced the undertaking at his own expence; and, after exhauſting all his reſources, and being refuſed aid from the corporation of London, he was enabled, by the aſſiſtance of the king, to bring it to completion. On September 29, 1613, the water was let into the New River Head, at Iſlington; but the projector was ruined by the expences, and it was long before the ſcheme was rendered uſeful and beneficial to the public. The New River is formed by the collected waters of ſeveral ſprings, which riſe at Chadwell, near Ware, Hertfordſhire, about 20 miles north-weſt from London. Theſe ſprings are collected into a large, open baſin of conſiderable depth, near which a ſtone is placed, with inſcriptions, implying that the ſtream was opened in 1608, and that from the Chadwell ſpring the river flows 40 miles. The original ſupply of water having been found inadequate to the conſumption, the mill-ſtream of the river Lea, which runs near it, was reſorted to; and after various diſputes and litigations between its proprietors and thoſe of the New River, the mill has at length become the property of the latter company, who have now an unreſtricted uſe of the water; ſo that the river Lea may be conſidered as one of the ſources. On a ſluice leading from it are flood-gates, with a building, in which a man is placed, whoſe conſtant employ is to raiſe or lower them, according to the fulneſs of the river below; and that he may not err in the quantity ſupplied, a gauge is fixed acroſs the ſluice, conſiſting of a ſtone of great bulk, under which all the water paſſes; ſo that the current is regulated with the greateſt exactneſs. To preſerve a proper level, the New River takes ſuch a winding courſe, that the length of the channel is nearly thirty-nine miles. Paſſing Ware, Amwell, Hoddeſdon, and Cheſhunt, it enters Middleſex near Waltham-Croſs; bending towards Enfield-Chaſe, it returns to the town of Enfield; and at Buſh-hill was formerly carried acroſs a valley, in a wooden aqueduct, or open trough, 660 feet in length, ſupported by arches; but the improvement in canal making has ſuggeſted a better mode to effect the purpoſe by means of a mound of earth, over which the river paſſes in a new channel, which was completed in the year 1785. Hence the river proceeds with devious bends to Hornſey, between which village and Highbury it was formerly conveyed in another wooden aqueduct, now ſuperſeded, like the other, by a bank of clay. Still winding, it reaches Stoke-Newington, and paſſes on to the eaſt ſide of Iſlington, where it has a ſubterraneous channel, for 200 yards beneath the ſtreet. Juſt before this part is a building, whence ſeveral mains, or pipes, are ſent to ſupply the eaſtern ſide of London. After paſſing under the road, the New River emerges and coaſts the ſouthern ſide of Iſlington, till it reaches its termination at the grand reſervoir, called the New River Head. The width of the river near Iſlington is fourteen feet and a half, the average depth four feet and a half, but the depth decreaſes on aſcending towards its ſource. The number of bridges which croſs the river in its whole courſe is about two hundred: in various places are ſluices to let off the waſte water; which, with other works, excited admiration in the earlier ſtage of this branch of mechanics, but are now overlooked in the wonders of canal navigation. Truly admirable are the contrivances for diſtributing the water through the various parts of London. From a circular baſin, now thrice its original ſize, which firſt receives it, the water is conveyed by ſluices into ſeveral large brick ciſterns; whence it paſſes through large wooden pipes to the ſeveral diſtricts, and is conveyed into the houſes by leaden pipes. At the New River Head is a building, containing two ſteam-engines and a water-engine for forcing the water to a higher reſervoir near Pentonville, and to another near Tottenham-court road, for diſtribution to the weſtern parts of the town. Near the former reſervoir, in a field, a conſpicuous object appears, the uſe of which is little known. It is an iron pipe, twelve feet high, and four feet eight inches in circumference, with a wooden tub placed on its top. It acts in the double capacity of an air and waſte water-pipe, and is uſeful in preventing the burſt-

ing of the pipes, which was formerly very frequent from the force of water, or from compreffed air. A new refervoir, communicating with that at Pentonville, has been recently conftructed by the fide of Tottenham-court-road, for the fupply of Mary-le-bone and its vicinity: the mains from it are iron pipes of four feet eight inches circumference.

The property of this great concern was originally divided into 72 fhares, of which 36 were vefted in fir Hugh Middleton, who was obliged to part with them to various perfons; thefe are termed adventurers' fhares. The other thirty-fix were vefted in the crown for the money advanced by king James towards the undertaking. Thefe were alienated by Charles I., and are called king's fhares; but as the crown had no concern in the management, fo the holders of thefe fhares are excluded from the direction. The original value of the fhares was 100*l.* each, but fo difcouraging were the firft profpects, that they fell to a very low price. At prefent they are worth an hundred times their firft value: a rife in property fcarcely to be parallelled, and demonftrative of the increafe of buildings in the capital. The management of the company's affairs is vefted, by charter, in twenty-nine holders of adventurers' fhares, who form a board. The officers are, a governor, deputy-governor, a treafurer, and a clerk. Few public companies furpafs this in property and extent of concerns. The conftant repairs and improvements employ a vaft number of men and horfes; and the whole fyftem of the diftribution of the water is fo complicated, as to require the utmoft fkill and attention on the part of the furveyor and other officers.

The New River is a confiderable ornament to many feats and pleafure-grounds in its courfe; though it has too much canal-like regularity to be truly picturefque. It is likewife of great utility in affording a fupply of water for cattle, and for various other purpofes. Hunter's Hiftory of London and its Environs, 4to. 1808. Brayley's Hiftory of Middlefex and London, 8vo. 1810-13.

Newton

NEWTON, *Sir* ISAAC, the moſt illuſtrious of philoſophers and mathematicians that the world ever produced, and who, on account of his well-earned celebrity, has been denominated the "Prince of Philoſophers," was born on Chriſtmas-day 1642, at Woolſthorpe, a hamlet in Lincolnſhire, about ſix miles ſouth of Grantham. His father cultivated his own paternal eſtate, but is repreſented as being a very weak and unſteady man, who died three months before the birth of his only ſon Iſaac, the ſubject of the preſent article. Mrs. Newton, though ſhe married again, was particularly attentive to the education of her firſt-born, and had him carefully inſtructed in the elements of learning. At the grammar-ſchool of Grantham he laid a ſolid foundation of claſſical learning, and gave deciſive marks of his natural genius. Dr. Stukely, in ſpeaking of him, ſays, "Every one that knew ſir Iſaac, or have heard ſpeak of him here, recount the pregnancy of his parts when a boy, his ſtrange inventions, and extraordinary inclination for mechanics, that, inſtead of playing with other boys, when out of ſchool, he always buſied himſelf in making knicknacks, and models of wood in many kinds; for which purpoſe he had got little ſaws, hatchets, and hammers, and a whole ſhop." The moſt trifling circumſtances, relating to ſo vaſt a genius as ſir Iſaac Newton exhibited, are deſerving of record: hence may be mentioned his very early attention to natural objects and inveſtigation. He had, for inſtance, when a very little

child, a rude method of meaſuring the force of the wind, by obſerving how much farther he could leap in the direction of a ſtrong breeze, than he could when he jumped againſt the wind. When he quitted the grammar-ſchool, he was taken home to be inſtructed in rural affairs, in order that he might hereafter be capable of managing his own eſtate with advantage. It was, however, ſoon diſcovered that he had higher objects in view than the mere cultivation of land, and attending to domeſtic concerns: he was perpetually found reading books, which were ſuppoſed to be beyond his capacity. He had, previouſly to this, probably laid it down as a maxim, that what one man could write, that was in itſelf intelligible, another might, by a certain portion of application, come to underſtand. Being once ſent to Grantham market, he was diſcovered by his uncle, in a hay-loft, working a mathematical problem; which ſatisfied this relation that his deſire of knowledge was invincible, and that a regard ought to be paid to the turn of his mind: he, therefore, without heſitation, was allowed to enter himſelf, in the year 1660, of Trinity-college, Cambridge. He was now 18 years of age, and entering upon his courſe with all the ardour of enthuſiaſm, much might be expected from him; but, as we ſhall ſee, he outran all expectation, and ſet at defiance the calculations of his moſt ſanguine friends. The activity of his genius, and excellence of his talents, acquired for him the notice of the moſt conſiderable mathematicians in the univerſity, among whom was Mr. (afterwards Dr.) Barrow, at that time a fellow of Trinity-college. The friendſhip thus begun between theſe two perſons, was continued till the hand of death ſeparated them. Newton began his ſtudies with the "Elements of Euclid;" but theſe did not detain him long. To him there was no "Pons Aſinorum," no difficulty that impeded his progreſs a ſingle moment: he ſaw the truth of each propoſition, it has been ſaid upon unqueſtionable authority, as ſoon as he had read the enunciation, and examined the figure to which it referred. The beautiful and ſublime truths of common geometry did not, to Newton, lie deep in a well: they ſeemed inſtantly to faſten on his mind, and, as he thought, to urge him on to more difficult ſteps in the progreſs of ſcience. Afterwards, however, the ingenuouſneſs of his mind led him to regret that he had not ſtopped longer at the gates of knowledge;—that he had not reſted a while in the avenues, to contemplate the beauties and excellencies of the plans and outworks, before he had proceeded into the interior;—that he had not examined with a more minute attention Euclid's method of demonſtration, and the means by which he had contrived to connect every part of his book, ſo as to make a ſyſtem or ſeries of truths depending upon one another, and the whole reſting on definitions and axioms; though the axioms themſelves will, if cloſely examined, be found to be only definitions: ſo that the whole of Euclid's Elements may be ſafely ſaid to depend entirely on definitions, which proves how important it is for ſtudents in geometry, not endowed with peculiar mathematical ſagacity, to ſtudy with the utmoſt care the definitions, and to proceed from one ſtep to another with the greateſt deliberation. Newton, as we have ſeen, did not ſtand in need of this precaution; yet he regretted in after life, that "he had committed a miſtake in the commencement of his mathematical ſtudies, in applying himſelf to the works of Des Cartes, and other algebraical writers, before he had conſidered the Elements of Euclid with that attention which ſo excellent a writer deſerves." At this period the works of Des Cartes were much in faſhion, which of courſe led our author to ſtudy them, attending at the ſame time to "Kepler's Optics," and to the "Arithmetica Infinitorum" of Dr. Wallis, making improvements and marginal notes upon them as he went along, which was his uſual method of ſtudying any author. The treatiſe of "Infinites," juſt referred to, ſet his invention to work; and was probably that which led him to his "New Method of infinite Series and Fluxions," and which was publiſhed in Latin; but which, in 1736, was tranſlated into Engliſh by Mr. Colſon, and printed by him, with a perpetual Commentary upon the whole book. In the year 1664 he took his degree of B.A., and about this period he turned his attention to the improvement of teleſcopes. Des Cartes aſſuming the commonly received opinion, that light was homogeneous, had, upon this principle, diſcovered the laws of refraction, and maintained that the perfection of teleſcopes depended on the diſcovery of a method of making glaſſes in elliptic, parabolic, or hyperbolic figures. Newton, therefore, in the year 1666, applied himſelf to the grinding of optical glaſſes of divers figures; at that time not ſuſpecting that light was other than an homogeneous ſubſtance. Not ſucceeding in various attempts which he made, he procured a glaſs priſm, for the purpoſe of examining the phenomena of colours, which had lately been diſcovered by Grimaldi. The vivid brightneſs of the colours produced by this experiment at firſt afforded him very great pleaſure; but when his ſurpriſe was over, and he came to examine them with philoſophical accuracy, he was aſtoniſhed at ſeeing them in an oblong form, which he thought ſhould be circular. He imputed the irregularity, at firſt, to ſome accidental circumſtance of which he was not aware: when, however, he found the reſult uniformly the ſame in every experiment, he purſued the inquiry, till at length he diſcovered an infallible method of deciding the point, which produced his "New Theory of Light and Colours." This theory, unexpected and wonderful as it was, did not ſatisfy him; but urged him on to inquire into the uſe that might be made of it in improving teleſcopes, which was his firſt deſign. Having now aſcertained that light was not homogeneous, but a heterogeneous mixture of differently refrangible rays, he computed the errors ariſing from this different refrangibility; and finding them to exceed ſome hundreds of times thoſe occaſioned by the circular figure of the glaſſes, he began to ſtudy the ſubject of reflection with the utmoſt care. He was now convinced that optical inſtruments might be brought to any degree of perfection, provided a ſubſtance could be found which would bear a poliſh as finely as glaſs, and reflect as much light as glaſs tranſmits, and that the art of giving it a parabolic figure could be attained. Theſe deſiderata he did not ſuppoſe could be realized; but while his mind was intently occupied by the ſpeculation, the breaking out of the plague at Cambridge, in 1665, obliged him ſuddenly to quit his ſtudies and his books, and retire into the country. From this time, for a ſpace of about two years, Newton lived, in a great degree, ſecluded from the converſation and the ſociety of thoſe perſons, by whom he might have been aſſiſted in his ſtudies; but the activity of his genius would not permit him to ſpend this period without engaging in important philoſophical inquiries. It was, indeed, in the ſolitude now referred to, that the hint occurred which gave riſe to the Syſtem of the World, which is the main ſubject of his "Principia." As he was ſitting alone in a garden, an apple falling from a tree, led his thoughts to the ſubject of gravity; and reflecting on the operation of that principle, he began to conſider that, as this power is not found ſenſibly diminiſhed at the remoteſt diſtance from the centre of the earth to which we can riſe, neither at the tops of the loftieſt buildings, nor on the ſummits of the higheſt mountains, it was reaſonable to conclude that it muſt extend much farther than was uſually imagined. "Why not," ſaid he to himſelf, "as high as the moon? and if ſo, her motion muſt be

influenced by it. Perhaps ſhe is retained in her orbit by it. Though the power of gravity is not ſenſibly weakened in the little change of diſtance at which we can place ourſelves from the centre of the earth, yet it is very poſſible that, as high as the moon, this power may differ in ſtrength much from what it is here." He made the calculation; but having gone upon wrong data, in ſuppoſing 60 miles to make a degree, inſtead of $69\frac{1}{2}$, the reſult did not come out according to his expectations: he therefore concluded, that ſome other cauſes muſt be joined with the action of the power of gravity on the moon; and on this account he laid aſide, for that time, any further thoughts upon the ſubject. On his return to Cambridge, in 1667, he was elected fellow of his college, and took his degree of M.A. He now was anxious to improve the teleſcope, and had made preparations for his experiments, when his attention was interrupted by the buſineſs connected with the profeſſorſhip of mathematics, which Dr. Barrow reſigned to him in 1669. Having entered upon the office, he made his diſcoveries in optics the ſubject of his lectures, for the firſt three years after his appointment to the mathematical chair: and having brought his theory of light and colours to a conſiderable degree of perfection, he communicated it to the Royal Society, of which he was a member; and it was afterwards publiſhed in their Tranſactions, for the month of February 1672. The publication gave riſe to a controverſy that occaſioned him much uneaſineſs, ſo that he reſolved not to publiſh any thing further, for a time at leaſt, on the ſubject; and accordingly he laid aſide his optical lectures, although they were actually prepared ready for the preſs. His analyſis by infinite ſeries underwent the ſame fate. He now reſumed his teleſcope, and obſerving that there was no abſolute neceſſity for the parabolic figure of the glaſſes, he completed another inſtrument of this kind. This anſwered his purpoſe ſo well, that, though it was only ſix inches long, he had ſeen with it the ſatellites of Jupiter, and the different phaſes of Venus. This teleſcope he ſent to the Royal Society, at their requeſt, together with a deſcription of it, publiſhed in the Philoſophical Tranſactions for March 1672.

During this year Mr. Newton publiſhed at Cambridge "Bernardi Varenii Geographia generalis, in qua affectiones generales Telluris explicantur; aucta et illuſtrata ab J. Newton." From this time till 1679 our author maintained a correſpondence with Mr. Henry Oldenburg, ſecretary of the Royal Society, Mr. John Collins, Mr. Flamſteed, and Dr. Halley. During this period, at the requeſt of Leibnitz, he explained his invention of infinite ſeries, and ſhewed how far he had improved it by his method of fluxions, which, however, he ſtill concealed by a tranſpoſition of the letters that made up the fundamental propoſitions of it into an alphabetical order. The letters concerning this are inſerted in Collins's "Commercium Epiſtolicum," printed in 1712. In 1676-7, he diſcovered the grand propoſition, that, by a centripetal force acting reciprocally as the ſquare of the diſtance, a planet muſt revolve in an ellipſis, about the centre of force placed in its loweſt focus, and, by a radius drawn to that centre, deſcribe areas proportional to the times. About the year 1680 he made many aſtronomical obſervations upon the comet that then appeared; which, for ſome conſiderable time, he took not to be one and the ſame, but two different comets, contrary to the opinion of Mr. Flamſteed. He next reſumed his enquiries reſpecting the moon. As Picart had meaſured a degree of the earth in 1679, by uſing his meaſures, Newton was led to the inference that the moon is retained in her orbit ſolely by the power of gravity, and, conſequently, that this power decreaſes in the duplicate proportion of the diſtance, as he had formerly conjectured. Hence he found the line deſcribed by a falling body to be an ellipſis, having one focus in the centre of the earth; and aſcertaining, by this means, that the primary planets really moved in ſuch orbits as Kepler had ſuppoſed, he had the ſatisfaction to ſee that the enquiry, which he had undertaken, at firſt, from motives of mere curioſity, was capable of being applied to the moſt important purpoſes. Upon this he drew up, and afterwards demonſtrated, about a dozen propoſitions relating to the motions of the primary planets round the ſun, which he communicated to the Royal Society towards the cloſe of the year 1683. Shortly after this he ſet down to complete his great work, the "Principia," which was printed under the care of Dr. Halley, and publiſhed in the ſummer of 1687, under the title of "Philoſophiæ Naturalis Principia Mathematica." This treatiſe was compoſed by the illuſtrious author from ſcarcely any other materials than the few propoſitions above-mentioned, and in the ſpace of a year and a half: it has gone through a great number of editions, though it did not at firſt meet with that ſort of applauſe to which it was juſtly entitled. One reaſon of this was, that Des Cartes had then got full poſſeſſion of the world, and his philoſophy was ſuppoſed to be better adapted to common underſtandings. The "Principia," on the other hand, is in many places extremely difficult, owing to the number of ſteps which is left out in the demonſtrations, ſo that the beſt mathematicians were obliged to ſtudy it with care, before they could pretend to become maſters of this vaſt treaſure of human learning. And notwithſtanding the helps that we now have to the right underſtanding of the "Principia," in Maclaurin's and Pemberton's works; in the "Excerpta" of Dr. John Jebb, and in the Commentaries of the Jeſuits, publiſhed at Rome in four volumes quarto; ſtill it may be aſſumed that "none but mathematicians of a high order can completely comprehend the reaſonings contained in it. When, however, the true value of this work came to be known, the approbation which had been ſo ſlowly gained became univerſal, and nothing was heard from all quarters, but admiration of what ſeemed to be the production of a celeſtial intelligence, rather than of a man." "Does Mr. Newton eat, or drink, or ſleep like other men?" ſaid the marquis de l'Hoſpital, one of the greateſt mathematicians of the age, "I repreſent him to myſelf," he added, "as a celeſtial genius entirely diſengaged from matter."

A ſhort time before this work went to the preſs, the privileges of the univerſity of Cambridge were attacked by king James II., who ſent a *mandamus* to admit father Francis, an ignorant Benedictine monk, to a degree of M.A. On this occaſion Mr. Newton appeared among the moſt zealous and active defenders of that body, and was appointed one of the delegates to the high-commiſſion court, where they maintained their cauſe with ſuch reſolution and ſteadineſs that the king did not think it right to preſs the affair. Newton was, after this, choſen one of the repreſentatives of the univerſity in the convention-parliament of 1688, the ſeſſions of which he attended till its diſſolution. In 1696, Mr Newton was appointed to the office of warden of the mint, and in this ſituation he rendered very important ſervice to the nation, and was properly rewarded, in a few years, with the appointment of maſter of the mint, a place worth 1200*l.* *per annum*, which he held during the remainder of his life. Upon the promotion he reſigned the mathematical chair at Cambridge, and was ſucceeded in it by Mr. William Whiſton. In 1699 he was elected a foreign member of the Royal Academy of Sciences at Paris, and in 1703 he was choſen preſident of the Royal Society of London, and retained that honourable office till his death. In the following year he publiſhed his "Optics; or A Treatiſe of the Reflections,

Refractions, Inflections, and Colours of Light." This work was the result of his occasional labours for thirty years in bringing the experiments, on which his "New Theory of Light and Colours" is founded, to that degree of certainty and exactness which alone could satisfy himself. This seems to have been his favourite invention: he was the first person who conceived the idea, and engaged in the subtile and delicate study of the anatomy of light; who dissected a ray of light into its primary constituent particles, which then admitted of no farther separation; who discovered the different refrangibility of the particles thus separated, and that these constituent rays had each its own colour inherent in it. On this subject we could enlarge would our limits allow. With the approbation of the author, Dr. Samuel Clarke translated the "Optics" into the Latin language, and he did the business so much to the satisfaction of Mr. Newton, that he presented him with 500*l.* for his labour. It was published in 1706. With the first edition of his Optics, the author published his "Quadratures of Curves," which may be regarded as the earliest appearance, in print, of his Method of Fluxions, which he had invented in the years 1665 and 1666. M. Leibnitz had, since the year 1684, endeavoured to impress the world with the persuasion, that Newton had borrowed this invention from his "Differential Method;" when, therefore, our illustrious countryman laid claim to his own discovery it led to much altercation, but the learned world in general decided in favour of Newton; and Fontenelle, in speaking on the subject, says, "Sir Isaac was, by many years, the first inventor. M. Leibnitz, on the other side, was the first who published this method of calculation; and if he took it from sir Isaac Newton, he resembled Prometheus in the fable, who stole fire from heaven that he might communicate it to men." See our article KEILL, *John*.

In the year 1705, queen Anne conferred on Mr. Newton the honour of knighthood: two years after this, Mr. Whiston, by our author's permission, published his Algebraical Lectures, under the title of "Arithmetica Universalis, sive de Compositione et Resolutione Arithmeticæ Liber," which work was translated into English by Mr. Raphson. In 1711, our author's "Analysis per Quantitatum Series, Fluxiones et Differentias, cum Enumeratione Linearum tertii Ordinis" was published by William Jones, esq. F.R.S., who met with a copy among the papers of Mr. Collins, to whom it had been communicated by Dr. Barrow. It was published in consequence of the dispute relating to the invention of fluxions, which also occasioned the printing, in 1712, by the consent of sir Isaac, a Collection of Letters, already referred to, by him and others in that controversy, under the title of "Commercium Epistolicum D. Johannis Collins et aliorum, de Analysi promota, jussu Societatis Regiæ in Lucem editum." In the year 1715, M. Leibnitz, with the view of gaining credit to the pretension that the "Method of Fluxions" had been borrowed from his "Differential Method," attempted to baffle sir Isaac Newton's mathematical skill by his famous problem of his Trajectories, which he proposed to the English by way of challenge; but though it was the most difficult proposition which his ingenuity, after much study, was able to devise, the solution of it proved scarcely more than an amusement to Newton. The problem was received by him at four o'clock in the afternoon, as he was returning from the mint, and though he was extremely fatigued with business, yet he finished the solution of it before he retired to bed.

Upon the accession of king George I. to the British throne, sir Isaac was particularly noticed at court, and was specially introduced to the princess of Wales, afterwards queen Caroline, who took great delight in literary and philosophical enquiries, and in the conversation of men distinguished by their talents and knowledge. With that of our author she was always peculiarly gratified, deriving from it that full satisfaction in every difficulty, which she had in vain sought for elsewhere, and she did not scruple to say that she thought herself happy in coming into the world at a juncture of time which put it in her power to converse with sir Isaac Newton. At the solicitations of this princess he drew up an abstract of his "Chronology," and communicated a copy of it to the abbé Conti, upon the promise of his keeping it secret; instead of which he had it translated and printed at Paris, under the title of "Abregé de Chronologie de M. Le Chevalier Newton, fait par lui-même et traduit sur le Manuscript Anglois:" a copy was sent to sir Isaac by the bookseller, who printed it, under the pretence of asking his consent to the publication; but though he gave a direct and most explicit denial, the work was sent into the world in the course of the year. He accordingly found it necessary to enter into a vindication of himself, which was inserted in the 34th volume of the Philosophical Transactions, under the title of "Remarks upon the Observations made upon a Chronological Index of sir Isaac Newton, translated into French by the Observator, and published at Paris." Of this paper a translation appeared at Paris in 1726, with a letter of the abbé Conti in answer to it. In the same year, likewise, some dissertations were published at Paris by father Souciet, against the "Chronological Index," a reply to which, by Dr. Halley, was given in the 397th Number of the Phil. Transf.

Our philosopher enjoyed a regular and pretty equal state of health until he attained his eightieth year, when he began to decline: his illness was supposed to be occasioned by a stone in the bladder, which at times was attended with such paroxysms of pain as caused large drops of sweat to roll down his face. During these attacks he was never heard to utter the least complaint, nor to express any impatience, and as soon as he had a moment's ease he would smile and converse with his usual cheerfulness. Till this period he had always read and written for several hours in a day, but he was now rendered incapable of much application. On the morning of the 18th of March 1726-7, he read the newspaper, and conversed for a considerable time with Dr. Mead, his physician, having then the perfect use of his faculties, of which he was, however, deprived in the course of the following night, and he breathed his last on the 20th of the same month, being in the 85th year of his age. Splendid funeral honours were paid to his remains, in a manner, in every respect, suitable to his extraordinary merit, and that high estimation in which he was deservedly held in every part of Europe. His body lay in state in the Jerusalem chamber, adjoining the house of lords; and at the interment the pall was supported by the lord chancellor, the dukes of Montrose and Roxburgh, and the earls of Pembroke, Sussex, and Macclesfield.

In contemplating the character and genius of this great man, it is not easy to determine whether sagacity, penetration, strength, or diligence had the greatest share in his composition. He entertained a very modest opinion of his own abilities, saying, when complimented on the extraordinary powers of his mind, if he had done any thing worthy of notice, and of service to the world, it was owing more to his industry and patience of thought, than to any extraordinary sagacity. "I keep the subject constantly before me," said he, "and wait till the first dawnings open slowly, by little and little, into a full and clear light." When engaged in the solution of difficult problems, he was often so completely lost to the world as to forget the common

concerns of life. He has been known to fit for hours on the fide of his bed with his clothes half on and half off, abforbed in thought; at other times he has gone through the day without food, having forgotten the wants of nature, in the contemplation of fome mathematical truth. Our author's temper is faid to have been fo mild and equal, that fcarcely any accident could difturb it. One inftance in particular is mentioned of this difpofition. He had a favourite little dog called Diamond, which being left in his ftudy, had overfet a lighted candle, among his papers, and burnt the almoft finifhed labours of many years. This lofs was irretrievable, yet the philofopher only exclaimed, "O Diamond! Diamond! thou little knoweft the mifchief thou haft done."

It fhould be noted that fir Ifaac Newton was candid and affable, and always put himfelf upon a level with his company. He never thought either his own merit or reputation fufficient to excufe him from any of the common offices of focial life; and no fingularities, either natural or affected, diftinguifhed him from other men. With refpect to his religious fentiments, he was unqueftionably a firm believer in the truth of divine revelation, and a ferious, rational Chriftian. His difcoveries concerning the frame and fyftem of the univerfe, he employed to demonftrate the exiftence of a God, againft Atheifm of all kinds, and to illuftrate his power and wifdom in the creation of the world; and he applied himfelf with the utmoft attention to the ftudy of the facred writings, and confidered the feveral parts of them with uncommon exactnefs. He adhered, outwardly, to the communion of the church of England, though he did not believe in all its doctrines: with refpect to the perfon of Chrift, there feems no doubt that fir Ifaac Newton was inclined to Unitarianifm; for this we have the teftimony of his friend and co-operator in the mint, Mr. Hopton Haynes, independently of his own writings. Sir Ifaac was never married, and Fontenelle fays he never had time to think of it, taken up as he was, at firft in profound and continual ftudy, and afterwards employed in an important and confiderable poft, which left no vacancy in his life, nor any occafion for domeftic fociety. He died rich, and inteftate. His library has defcended to the prefent times, in his own family, and at the moment of writing this article (March 27, 1813,) it is felling by auction in London, by order of the executors of Mrs. Ann Newton. (See NEWTONIAN *Philofophy*.) For a notice of our author's works not mentioned in this article the reader is referred to the Biographia Britannica: the moft complete edition of them, collectively, was given to the public by Dr. Horfley in 1785, in 5 vols. royal 4to. See HORSLEY. Biog. Brit. Pemberton's and Maclaurin's Views, &c.

Nickel

NICKEL, in *Chemiſtry*, a ſimple ſubſtance, and a metal of a white colour. When obtained perfectly pure it is malleable. Its luſtre is agreeable, and at ſome period it may become of importance in the arts, and in domeſtic economy.

Aſſay and Analyſis of Nickel.—This metal is generally obtained from a mineral of a reddiſh-brown colour, frequently ſpotted with green, found plentifully in different parts of Germany. This ore was formerly thought to be copper ore, from its green ſpots, but in conſequence of its affording no copper, it obtained the name of *kupfer nickel*, which means falſe copper. This mineral chiefly conſiſts of nickel and ſulphur, but contains more or leſs of arſenic, cobalt, and iron. The firſt experiments to aſcertain the nature of this mineral were by Cronſtedt in 1751, who was of opinion that he had obtained a peculiar metal from it, to which he gave the name of nickel. What he procured, however, was not pure nickel, in conſequence of which the authority of this chemiſt was doubted by Sage and Monnet. This point was at laſt finally ſettled by Bergman, who proved it to be a new metal. The experiments were publiſhed in 1775. The purification of this metal has been ſince carried to a greater extent by different chemiſts. The following is the moſt approved proceſs for obtaining the oxyd of this metal in a ſtate of purity, from which the metal is afterwards eaſily obtained.

After the ore above-mentioned has been roaſted with charcoal, which may probably expel ſome of the arſenic, it muſt be reduced to a fine powder, and treated with nitric acid. The remaining ſulphur will be ſeparated, or, with the arſenic, converted into ſulphuric and arſenic acids. If to a ſolution nitrat of lead be added, theſe acids will be precipitated by the lead in the ſtate of ſulphat and arſeniat of lead. If too much nitrat of lead be added, the lead may be precipitated by adding ſmall portions of ſulphuric or rather ſulphat of ſoda, till no more precipitates take place. The ſolution now contains nickel, iron, and perhaps cobalt and copper. The copper may be ſeparated by a clean bar of iron. The ſolution muſt now be treated with carbonat of potaſh, by which the three oxyds will be precipitated together. Theſe being waſhed, the nickel and cobalt may be diſſolved in pure ammonia, while the oxyd of iron will be left behind. This ammoniacal ſolution is next heated, till the ammonia is driven off, which is known by its ceaſing to tinge turmeric paper brown. If to theſe oxyds pure potaſh be added, the oxyd of cobalt will be diſſolved, while that of nickel will be left in a ſtate of purity. The oxyd of nickel is now to be made into a paſte with oil or fat, and introduced into a crucible, with ſome black flux. The crucible ſhould be lined with charcoal, and provided with a cloſe cover; the whole muſt be heated ſtrongly in a ſmith's forge for more than an hour. On cooling a button of pure nickel will be found.

This metal, as has been remarked, is of an agreeable white colour, poſſeſſing conſiderable hardneſs and luſtre. Its ſpecific gravity is about 8.3, which increaſes with hammering. It is ſaid to be capable of being hammered into ſheets not thinner than $\frac{1}{100}$dth of an inch. It is now generally believed to be magnetic, like iron. It does not fuſe at a temperature leſs than 160° of Wedgewood. It poſſeſſes the valuable property of not being changed by expoſure to the air, nor by immerſion in water, at the common temperature. When, however, it is expoſed to a tolerable heat, it becomes tarniſhed, and ultimately covered with oxyd. A much ſtronger heat ſets this oxygen free, as is the caſe with the noble metals.

The oxyds of nickel at preſent known are two, namely, the grey and the black. Chemiſts are at preſent divided in opinion whether the green oxyd be the firſt or ſecond oxyd. Dalton ſeems to be uncertain as to this point, the atom of oxygen being 7. And ſince the analyſis of Richter gives 78 of metal to 22 of oxygen, we ſhall have, conſidering the grey oxyd the firſt oxyd, $\frac{x}{7} = \frac{78}{22}$, and $x = \frac{78 \times 7}{22}, = 24.81$, the weight of the atom of nickel. If it be conſidered as the ſecond oxyd, then $\frac{x}{14} = \frac{78}{22}$, and $x = 49.62$, the weight of the atom of nickel. Theſe numbers are ſo near 25 and 50, that Dalton has given with doubt 25 or 50 for the atom of nickel. Sir Humphrey Davy thinks the grey oxyd the ſecond oxyd, from the number he gives for nickel agreeing alſo with the ſulphuret. We have, therefore, good ground for ſtating the weight of an atom of nickel at 50. From theſe data the firſt oxyd will conſiſt of 50 to 7, or in the 100, there is 87.7 nickel, and 12.3 oxygen. The ſecond, 50 to 14, or 100 will give 78.1 nickel, and 21.9 oxygen. The

third, or black oxyd, will be 50 nickel to 21 oxygen, or in 100, there will be 70 of nickel, and 30 of oxygen.

The second oxyd is obtained by dissolving nickel in nitric acid, and precipitating the oxyd by means of potash. This precipitate is not the pure oxyd, but an hydrated oxyd, containing, according to sir Humphrey Davy, $\frac{1}{4}$th its weight of water. When this hydrat is heated to ignition, the water is separated, leaving the grey oxyd. When the oxymuriatic acid gas is passed through water mixed with the latter oxyd, it becomes converted into the black oxyd.

Nickel combines with sulphur. We are indebted to Mr. E. Davy for the proportions of its combination with sulphur, which he states at 34 sulphur to 66 nickel. This sulphuret must be considered as 2 atoms of sulphur, 2×13 to 1, of nickel, 50, for $\frac{50 + 26}{26} = \frac{100}{34.2}$, or 34.2 oxygen to 65.8 nickel. This very strongly confirms the truth of the number 50 for the weight of the atom of this metal. From the same authority there appears to be another sulphuret, formed by heating the grey oxyd with sulphur, consisting of 56.5 nickel, and 43.5 oxygen. This will be 3×13 to 50, which gives 43.8 sulphur, and 56.2 nickel. Nothing can be more satisfactory than this almost exact agreement between theory and practice. The first sulphuret will be 13 to 50, or in 100, 20.6 sulphur, and 79.4 nickel. According to the authority of Thenard, phosphorus combines with nickel in the proportions of 17 phosphorus to 83 of nickel. Theory would give the first phosphuret 50 to 9, or *per cent.* 15.3 phosphorus and 84.7 nickel. The second sulphuret will be 50 to 2×9, or *per cent.* 73.5 nickel, and 26.5 phosphorus. The combination of nickel with hydrogen, nitrogen, carbon, and the base of the boracic acid, is not known. It forms alloys with some of the metals, but, these compounds have been little examined. Since nickel is a malleable metal, and difficult of fusion, some fusible alloy with it might be of importance. Its alloy with gold was tried by Mr. Hatchett in the proportions of 11 gold to 1 of nickel, which was brittle, and of the colour of brass. Sir H. Davy speaks highly of its alloy with iron: its colour approaches silver as the nickel prevails, while the malleability of the iron is not impaired. It is also less liable to rust than iron. The same author observes that iron in meteoric stones is alloyed with nickel from 1.5 to 17 *per cent.* of the latter

Salts of Nickel, or the Combination of its Oxyds with Acids.—The few facts of which we are in possession of combinations of this substance with acids, are not strictly to be relied upon, from the circumstance of the experiments being made upon impure nickel.

Sulphat of Nickel.—Sulphuric acid has little action upon nickel, but it dissolves its oxyd, forming a salt, the solution of which is of a beautiful green colour. By evaporation it affords prismatic crystals, which afterwards effloresce and become opaque. The composition of this salt has not been ascertained, but it may be inferred with some hope of truth, from the near coincidence of the other compounds of nickel with theory. The oxyd which unites with the acid is doubtless the grey; hence $34 + 50 + 14$ will constitute the salt, or 34 acid to 64 oxyd. This will give *per cent.* 34.7 acid, and 65.3 of base.

Nitrat of Nickel.—Nitric acid oxydates and dissolves nickel. The solution is of a green colour, and affords rhomboidal crystals. This salt is first deliquescent, and afterwards falls to powder, by losing its acid, the atom of nitric acid being 19; and since the soluble nitrats mostly contain two atoms of acid, it will be constituted by 2×19 acid to 64 of oxyd.

Muriat of Nickel.—The muriatic acid acts feebly upon nickel. With the aid of nitric acid, however, it becomes oxydated, and the muriatic acid dissolves it, forming a green solution, which at first crystallises in the form of rhomboidal prisms. These are soon acted upon by the air, and ultimately lose the acid, like the nitrat, the atom of muriatic acid being 22. This salt will consist of 22 acid, and 64 of base.

Phosphat of Nickel.—The phosphoric acid takes up a very small quantity of the oxyd of nickel, and hence is perhaps almost an insoluble salt. Hence the best way of forming it will be by adding phosphat of soda to nitrat of nickel. It will be formed by 23 of acid, and 64 base.

Fluat of Nickel.—This salt is soluble, and affords green crystals. It will consist of 15 acid, and 64 base.

Borat of Nickel.—This salt is very little known. It may be formed by mixing borat of soda with nitrat of nickel.

Carbonat of Nickel.—This salt is mentioned by Bergman, who formed it by adding an alkaline carbonat to the nitrat of nickel. He found it to consist of 56.4 acid and water, and 43.6 of base.

Acetat of Nickel.—Oxyd of nickel dissolves in acetic acid, forming a soluble salt, which crystallises in a rhomboidal form, and of a green colour.

Oxalat of Nickel.—The oxalic acid slightly attacks nickel, with which it forms a green powder, from the salt being insoluble. It should be formed by adding oxalat of soda to a nitrat of nickel. The salt falls down in the form of green powder.

Tartrat of Nickel has not been examined.

Arseniat of Nickel.—This is a soluble salt, but little known.

Molybdat of Nickel.—This salt is in the form of white powder, and probably insoluble.

Sulphat of Nickel and Potash.—This is a triple salt, discovered by Proust. It is formed by adding potash to the sulphat of nickel. By evaporation it easily crystallises in the form of prisms of a beautiful green colour. It has a sweetish taste.

Sulphat of Nickel and Ammonia.—Using ammonia as the potash is used in the last salt, forms a triple salt of a green colour, affording flat prismatic crystals.

Sulphat of Nickel and Iron.—This salt is formed by adding nitrat of nickel to sulphat of iron, or by dissolving the two oxyds in sulphuric acid. It affords green crystals, which are efflorescent.

A triple salt is also formed by adding an excess of ammonia to nitrat of nickel, consisting of nitric acid united with oxyd of nickel and ammonia. It affords green coloured crystals. This salt has the peculiar property of being decomposed by the alkalies, at least the oxyd is not precipitated. This property is of some importance for separating nickel from other metals. The metal is, however, precipitated by the hydro-sulphurets. For the principles on which the numbers representing the relative weights of the atoms of bodies are calculated, see PROPORTION *of Chemical Compounds*

Nitrats

NITRATS, in *Chemistry*, that genus of salts formed by the nitric acid with the different saline bases. The great facility with which the nitric acid is decomposed by the different inflammable bodies, is the cause of the marked character of detonation possessed by these compounds. The heat and light furnished during the detonation of the nitrats with inflammable bodies, as in the case of gunpowder, has been used as a successful argument against the Lavoiserian doctrine of combustion. If the oxygen be the source of the light and heat, and that only when it passes from the elastic to the solid or liquid form, it will be evident, that cold ought to be produced from the detonation of the nitrats. It is now, however, pretty generally admitted, that bodies do not give out caloric in the ratio of their condensation, but in proportion to the change of specific heat during the chemical change. It is therefore highly probable, that no great quantity of heat is given out during the combination of nitrogen with oxygen to form nitric acid. It must also be admitted, that the inflammable bodies themselves give out a quantity of caloric during the detonation with nitre. A similar conclusion must be drawn in the action between oxymuriat of potash and the inflammable bodies.

The greatest proportion of the soluble nitrats contain 2 atoms of acid to 1 of base, so that instead of considering the acid as 19, the weight of 1 atom, hydrogen being 1, it will be generally found 38. Those salts, which have been called sub-nitrats, are generally nitrats, in which the acid is 19. We shall now give an account of some of the nitrats that have been omitted in their proper places, and refer to others under their respective bases. Of these the most important is the *nitrat* of POTASH; which see.

NITRAT *of Alumine*. This salt is prepared by dissolving alumine in nitric acid, and evaporating the solution till the salt crystallises. In this salt there is always an excess of acid, and it is therefore sometimes reckoned a super-nitrat. It crystallises with great difficulty in thin soft plates, which have but little brilliancy. It has an acid and also an astringent taste. Its specific gravity, according to Hassenfratz, is 1.645. It is very soluble in water, and when the fluid is evaporated, it is converted into a glutinous mass of the consistence of honey. It often assumes on cooling the form of a jelly. When exposed to the air, it very soon attracts moisture and deliquesces. When heated, the acid is disengaged with great facility, and the earth remains behind.

NITRAT *of Ammonia*. This salt was formerly distinguished by the names of *nitrum semivolatile*, and *nitrum flammans*. Berthollet examined it in the course of his experiments on the component parts of nitric acid, and sir Humphrey Davy, in his researches, has added considerably to our knowledge of its composition and decomposition. It may be prepared by dissolving carbonat of ammonia in diluted nitric acid, and evaporating the solution till the salt crystallises. The appearance of this salt varies much according to the temperature at which its solution is evaporated. In a heat of from 70° to 100°, and by slow cooling, it is obtained in six-sided prisms, terminated by long six-sided pyramids. When the solution is evaporated at the temperature, of boiling water, or 212°, the crystals are channelled and have a fibrous texture, or they are formed of long elastic threads. When dried in a heat of about 300°, it assumes the form of a white and very compact mass. These differences are unquestionably owing to different proportions of water of crystallization, which the salt contains. Nitrat of ammonia has a very acrid, bitter, and disagreeable taste. Its specific gravity is, according to Hassenfratz, in the Annales de Chimie, 1.579. At the temperature of 60° it is soluble in two parts of water, and it dissolves in half its weight of boiling water. When exposed to the air, nitrat of ammonia soon attracts moisture and deliquesces. When it is heated in the state of crystals, it becomes fluid at a temperature below 300°, and at from 360° to 400° it boils without decomposition; but when heated to 450°, or higher, it is gradually decomposed without losing its water of crystallization. When this salt is decomposed in a temperature not exceeding 500°, it is wholly converted into nitrous oxyd and water. From the experiments of sir H. Davy these products are in about the proportion of four parts of gas to three of water. When exposed to a heat of 600°, and higher, it explodes, and is

totally decompoſed, being converted into nitrous gas, nitrous acid, water and azotic gas. Hence its name among the older chemiſts, *nitrum flammans*. Its conſtituent parts, according to ſir H. Davy, are

Acid	69.5	72.5	74.5
Baſe	18.4	19.3	19.8
Water	12.1	8.2	5.7
	100	100	100

In the firſt of theſe analyſes the ſalt was priſmatic; in the ſecond it was fibrous; and in the third it was compact. The chief uſe of this ſalt is for yielding NITROUS *Oxyd;* which ſee.

NITRAT *of Barytes* is uſually prepared by diſſolving native carbonat of barytes in nitric acid, or by decompoſing ſulphuret of barytes by means of nitric acid, and evaporating the filtered ſolution till the nitrat cryſtalliſes. Its cryſtals are regular octahedrons, and they often adhere to each other in the form of ſtars. Sometimes it is obtained in ſmall brilliant plates. Its ſpecific gravity is 29.2 nearly. It is very eaſily reduced to powder. Its taſte is hot, acrid, and auſtere. It is ſoluble in 12 parts of water at the temperature of 60°, and in about three or four parts of boiling water. As the ſolution cools, the ſalt may be obtained in cryſtals. It is ſcarcely at all altered by expoſure to the air. When thrown on burning coals it decrepitates, undergoes a kind of fuſion, and then becomes dry. When ſtrongly heated in a crucible, the whole acid is gradually driven off, and the barytes remains pure. It detonates leſs violently with combuſtibles than moſt of the nitrats. The conſtituents are given by Fourcroy and Vauquelin, in the Annales de Chimie, as follows:

Acid	38
Baſe	50
Water	12
	100

NITRAT *of Glucine*. See GLYCINE.

NITRAT *of Lime*. See LIME.

NITRAT *of Magneſia*. See MAGNESIA.

NITRAT *of Magneſia* and *Ammonia* was firſt deſcribed by Fourcroy in 1790, and is prepared by mixing together the ſolutions of nitrat of ammonia and nitrat of magneſia, or by decompoſing either of theſe ſalts in part by the baſe of the other. When the two ſalts are mixed together, the nitrat of ammonia and magneſia gradually precipitates in cryſtals. Theſe cryſtals are in the form of fine priſms; they have a bitter acrid ammoniacal taſte; are ſoluble in about 11 parts of water at the heat of 60°, and in leſs as the temperature is higher. When expoſed to the air, they gradually attract moiſture, but more ſlowly than either of their component parts. The phenomena, which this compound exhibits when heated, are ſimilar to thoſe which its component parts exhibit in like circumſtances. According to Fourcroy it is compoſed of

78 parts of nitrat of magneſia,
22 ———————— ammonia.

NITRAT *of Silver*, in the *Materia Medica*. See SILVER.

NITRAT *of Soda*. See SODA.

NITRAT *of Strontian*. See STRONTIAN.

NITRAT *of Yttria*. See YTTRIA.

NITRAT *of Zirconia*. See ZIRCONIA.

NITRAT *of Ammonia*, in *Agriculture*, a neutral ſaline ſubſtance formed by the combination of the nitric acid and ammonia, or volatile alkali. This ſubſtance cannot be obtained in ſufficient proportions for the purpoſes of agriculture, but is uſeful in the analyſis of ſoils.

NITRAT *of Iron*, a ſalt formed by the union of nitric acid with iron, but is a ſalt rarely preſented by nature: its properties or effects, as they may apply to agriculture, are not, lord Dundonald ſays, worthy of much obſervation.

NITRAT *of Lime*, is an earthy ſalt which conſiſts of the nitric acid and lime. It is found in the mother-earth of nitre manufactories, on old walls, and mixed with true native nitre in the kingdom of Naples. The pureſt is obtained by the artificial and direct combination of its conſtituent parts. And it is a ſaline ſubſtance, that is alſo found in the rubbiſh of old buildings, and in thoſe materials from which ſaltpetre is extracted: *viz.* animal and vegetable matters, which, with a due proportion of calcareous earth, have undergone the putrefactive proceſs, together with a ſubſequent, ſufficiently long, expoſure to atmoſpheric air. According to Dr. Home, it is likewiſe contained in what is commonly called hard-water, which, by his experiments, was found to promote the growth of plants in a much higher degree than ſoft-water. It is very ſoluble and deliqueſcent; it is decompoſed by fixed alkalies, and forms therewith nitrat of potaſh or ſaltpetre, and nitrat of ſoda, or cubic nitre.

NITRAT *of Magneſia*, is an earthy ſalt, compoſed of the nitric acid and pure magneſia. It is found native in the mother-earth of nitre manufactories, and on walls. It has been obtained artificially by direct and indirect combination.

Lord Dundonald remarks that no agricultural experiments have yet been made with this compound; it is a very deliqueſcent and ſoluble ſalt; and there is reaſon to expect, that it will produce effects in promoting vegetation, ſimilar to thoſe which may reſult from the application of the nitrat of lime.

It is decompoſed by alkalies and lime, and forms therewith nitrat of potaſh, nitrat of ſoda, and nitrat of lime.

NITRAT *of Potaſh*, a neutral ſalt, formed by the combination of nitric acid and potaſh, or the fixed vegetable alkali. It is found in the fiſſures of the lime-ſtone hills, near Molfetta, in the kingdom of Naples, in various waters, and even in rain: likewiſe in the freſh juices of many plants, ſuch as the heliotrope, pellitory, tobacco, and others. It is produced ſpontaneouſly wherever its alkaline baſis is expoſed to a free current of air, and to the exhalations of putreſcent vegetable and animal matter; as on damp walls, rubbiſh, the ordure of ſtables, dunghills, &c. In Spain, the Eaſt Indies, and near Lima, it is generated upon commons and uncultivated ground; and it is even aſſerted that in the ſouthern regions of Spain, ſaltpetre is found in the duſt of the high roads. Lord Dundonald, in his treatiſe on the Connection of Agriculture with Chemiſtry, ſtates "that it is conſtituted by the putrefaction and complete decompoſition of animal and vegetable ſubſtances, when mixed with calcareous matter and wood aſhes." It is found to promote vegetation, but is too expenſive to be uſed as a manure for land.

NITRAT *of Soda*, a very ſoluble ſubſtance, formed from the combination of the nitric acid and the mineral alkali, or ſoda, which, on account of the figure of its cryſtals, has obtained the name of *cubic*, or more properly, of rhomboidal nitre. Bergmann diſtinguiſhes it by the name of nitrated ſoda, and modern chemiſts by that of nitrat of ſoda. It has not hitherto been found in a native ſtate, but is always produced, either directly or indirectly, by the artificial combination of its conſtituent parts. "Lord Dundo-

nald supposes it capable of promoting vegetation in an equal degree with the nitrat of potash."

NITRE, in *Chemistry*, the *Materia Medica*, &c. See *Nitrat of Potash*, under POTASH.

NITRE, in *Agriculture*, a term formerly applied to a salt extracted in Persia and the East Indies, from certain earths that lie on the sides of hills; and artifically produced, in some parts of Europe, from animal and vegetable matters rotted together (with the addition of lime and ashes), and exposed for a length of time to the air, without the access of which nitre is never generated.

It was formerly supposed to have much influence in the business of vegetation. See NITRAT *of Potash*.

NITRE, *Alkalised*, is the fixed alkali remaining after the nitrous acid has been destroyed by its detonation with any inflammable matter. This alkali is generally called *fixed nitre*.

NITRE, *Ammoniacal*, is a neutral salt resulting from the combination of the nitrous acid, to the point of saturation, with volatile alkali. The acid, in the most concentrated state in which it is commonly met with, saturates about five-sixths its weight of vegetable fixed alkali.

NITRE, *Antimoniated*. See ANTIMONY.

NITRE, *Calcareous*, is a neutral salt, compounded of the nitrous acid combined to saturation with a calcareous earth; and generally called *nitre with an earthy basis*. This salt is very deliquescent, but incapable of a true crystallization. It has a poignant, acrid, and bitter taste. See NITRUM *Calcareum*.

NITRE, *Clyssus of*. See CLYSSUS.

NITRE, *Crystals of*. See CRYSTAL.

NITRE, *Cubic*, or *Quadrangular*, is a neutral salt, formed by the nitrous acid when saturated with mineral alkali. This crystallises not into a prismatic but a cubical figure, and sometimes into parallelepipedons, with rhomboidal faces. It is inferior to ordinary nitre, and never used.

NITRE, *Decoction of*, is prepared by boiling half an ounce of nitre, and two ounces of fine sugar, with a scruple of cochineal as a colouring material, in 2½ pints of water, till half a pint is wasted, and after standing to settle, the clear purplish-red liquor is poured off for use.

NITRE, *Diaphoretic, of Antimony*. See ANTIMONY.

NITRE, *Fixed by Arsenic*, is the alkali of nitre, the acid of which has been expelled in an open fire by means of arsenic, of which some portion is retained by the alkali. This may be employed as a flux, as it greatly assists vitrification.

NITRE, *Fixed by Coals*. See FIXED *Nitre*.

NITRE, *Fixed by Metals*, is the alkali of nitre separated from its acid, and mixed with the earth of the calcined metals.

NITRE, *Fixed by Tartar*, is the alkali of nitre and that of tartar mixed together by means of detonation. This is called the *white flux*.

NITRE, *Glauber's Spirit of*. See SPIRIT, and NITRIC *Acid*.

NITRES, *Metallic*, a general denomination that comprehends all neutral salts composed of the nitrous acid united with a metallic substance; the several kinds of which may be thus distinguished, *viz. nitre of silver*, called *lunar crystals*, *nitre of lead*, *nitre of mercury*, &c. The acid acts in general powerfully upon all metallic substances, but with remarkable differences, depending on the peculiar natures of the metals. It dissolves zinc, iron, copper, bismuth, lead, mercury, and silver, the most readily of all the acids; tin it dissolves imperfectly; regulus of antimony it only corrodes; gold and platina cannot be dissolved by nitrous acid alone, without the concurrence of marine acid.

NITRE, *Nitred*. See NITRUM *Nitratum*.

NITRE, *Purified*. See NITRUM *Purificatum*.

NITRE, *Spirit of*. See SPIRIT.

NITRE, *Troches of*, are made by grinding one part of the purified salt with three parts of fine sugar, and making up the mixture with mucilage of gum tragacanth.

NITRE, *Vegetating*. See NITRUM *Vegetans*.

NITRE, *Vitriolated*. See NITRUM *Vitriolatum*.

NITRIC ACID, in *Chemistry*, so called by the French chemists in 1787, is a compound of great value in the hands of the analytical chemist. Although this acid may be formed synthetically, in very small quantity, by passing electric sparks, in quick succession, through a mixture of oxygen and nitrogen gases, it is, for all useful purposes, obtained from nitre (nitrat of potash). It appears first to have been procured from this substance by Raymond Lully in the 13th century, by distilling it from a mixture of nitre and clay. This method is still practised in some manufactories, but it is more generally procured by decomposing the nitre by means of sulphuric acid, a process first discovered by Glauber.

Into a glass retort put two parts of nitre and one of sulphuric acid, of the specific gravity of 1.85. A capacious quelled receiver is now to be luted to the retort: the heat of a lamp or a sand-bath must then be gently applied. The nitric acid soon begins to be evolved, which condenses in the neck of the retort, and runs into the receiver, of a pale yellow colour. As the heat is increased, yellow fumes arise, and the vapour becomes more difficultly condensed. In this stage of the process some of the acid is decomposed into nitrous gas and oxygen gas. These elastic fluids render the quelled receiver, or a tube of safety, highly necessary. The last portion of acid is not brought off till the heat has been raised almost to redness.

The liquid obtained by this process was called by the old chemists spirit of nitre, and aquafortis. It is of a deep yellow or orange colour, and consists, if the materials employed be pure, of nitric acid mixed with nitrous gas, to which it owes its yellow colour; as when this gas is expelled by heat the acid becomes colourless as water.

In the large way, and for the purposes of the arts, this acid is made in extremely thick cast iron or earthen retorts, to which an earthen head is adapted, and connected with a range of proper condensers. The strength of the acid is varied by putting more or less water in the receivers. The nitric acid, thus made, generally contains sulphuric acid, and muriatic acid from the impurity of the nitrat employed. If the former, a solution of nitrat of barytes will occasion a white precipitate: if the latter, nitrat of silver will render it milky. The sulphuric acid may be separated by a second distillation from very pure nitre, equal in weight to an eighth of that originally employed; or by precipitating with nitrat of barytes, decanting the clear liquid, and distilling it. The muriatic acid may be separated by proceeding in the same way with nitrat of silver, or with litharge, decanting the clear liquor, and re-distilling it, leaving an eighth or tenth part in the retort. The acid for the last process should be condensed as much as possible, and the re-distillation conducted very slowly; and if it be stopped when half is come over, beautiful crystals of muriat of lead will be obtained on cooling the remainder, if litharge be used. Other methods are mentioned for the obtaining aquafortis or nitric acid. The following, which differs but little from that of Glauber, is given by sir Humphrey Davy in his Elements of Chemical Philosophy. "It is," he says, "procured, for the purpose of chemistry, by the distillation of nitre and oil of vitriol:

about two parts of nitre ſhould be uſed to one part of oil of vitriol, and the retort heated in a ſand-bath connected with a receiver kept cool by moiſtened cloths. This acid, thus obtained, is uſually coloured, but becomes pale by expoſure to air. If the nitre be dry, its ſpecific gravity is from 1.52 to 1.55. This ſubſtance acts with great violence on all metals anciently known, excepting gold and platina, and it cauſes volatile oils to inflame. When it is paſſed through a porcelain tube heated to redneſs, oxygen is given off, and nitrous acid gas; and the ſame effect is produced upon the reſidual acid, as if it had been mixed with water; ſo that it is proved to be compoſed of nitrous acid gas, oxygen of water: and *four* in volume of nitrous gas, and two of oxygen gas condenſed in water, I find abſorb one in volume of oxygen to become nitric acid." He further adds, that from his own experiments, compared with thoſe of Kirwan, Wenzel, and Berthollet, he thinks that the ſtrongeſt acids contain from 14 to 15 *per cent.* of water, and, according to the principles of the French nomenclature, they ought to be called nitro-nitric acids. Aquafortis, or hydro-nitric acid, when its ſpecific gravity is below 1.4, ſtrengthens by being boiled: when ſtronger than 1.45, it becomes weaker by boiling.

The nitre of commerce frequently contains ſome muriatic ſalts, which being decompoſed by the ſulphuric, in common with the nitre, the muriatic acid comes over mixed with the nitric. If an exceſs of ſulphuric acid be employed, and the heat be very great, the latter, more or leſs, is frequently diſtilled over, ſo that nitric acid is often contaminated with ſulphuric and muriatic acids. The preſence of the muriatic acid may be beſt avoided by carefully cryſtallizing the nitre to be employed. If at laſt it ſhould ſtill contain a little muriatic acid, it may be ſeparated by nitrat of ſilver. The ſulphuric acid may be ſeparated by re-diſtilling from a litharge, or barytes ſufficient to ſaturate all the ſulphuric acid. After the nitrous gas has been expelled by heat, the acid may be deemed pure. In this ſtate it is perfectly colourleſs, and of a ſtrong acid taſte, which, when diluted with water, is not unpleaſant. It ſhould be kept in a bottle coated on the outſide with black varniſh, or in a dark place. When it is expoſed to the light, oxygen gas is diſengaged, and the nitrous gas which is liberated tinges it of a yellow colour.

When expoſed to the air it appears to exhale white fumes. This is occaſioned by the great attraction of the acid for the moiſture of the atmoſphere.

To all animal ſubſtances it gives a beautiful yellow tinge.

The ſtrongeſt acid yet produced is not of greater ſpecific gravity than 1.62. Mr. Dalton informs us, that when its ſpecific gravity is 1.42, it boils at 248° of Fahrenheit. If it be ſtronger, the acid is diſtilled off; and if weaker, the water, till it comes to the above maximum. It corrodes animal and vegetable ſubſtances very ſpeedily, and the latter in the greateſt degree. The yellow colour it gives to them, excepting ſubſtances containing albumen, is not produced but when the acid is very ſtrong, and aſſiſted by heat. If it be added to the eſſential oils, they ſpeedily inflame, leaving behind a ſpongy coal. When it is poured upon powdered charcoal, very dry, it takes fire. The ſame effects take place with ſulphur and phoſphorus, at a certain temperature.

It is decompoſed by all the metals, excepting gold, platina, and titanium: hence it is an important agent in chemiſtry for oxydating moſt of theſe ſubſtances. Many of the metals, ſuch as zinc, iron, tin, &c. take the whole of the oxygen from it, while nitrogen alone is diſengaged. Others of the metals, ſuch as ſilver, mercury, copper, &c. deprive it of only one atom of oxygen, the nitrous gas being ſet free, producing red fumes with the preſence of oxygen. When it is poured on zinc, tin, or biſmuth, in a ſtate of fuſion, inflammation takes place. The ſame effect takes place in the cold when the metals are in fine powder.

Nitric acid, as has been deſcribed, is not to be regarded as the real acid, but a compound of real acid and water. The determination of real acid, in a given quantity of the liquid, has much engaged the attention of chemiſts. We are indebted to Kirwan, Davy, Bertholiet, and Dalton, for reſearches on this ſubject. The experiments of the firſt and laſt of theſe chemiſts appear to come neareſt the truth.

Mr. Kirwan deprived ſome carbonat of ſoda of its water of cryſtallization: 367 grains of a ſolution of this ſalt contained 50.05 grains. This was ſaturated with 147 grains of nitric acid, of the ſpecific gravity of 1.2754, equal, as he had aſcertained, to 67.179 grains, of the ſpecific gravity 1.5543, which he made his ſtandard. The carbonic acid evolved by adding nitric acid was 14 grains. To this ſolution he added 939 grains of water, which reduced it to the ſpecific gravity 1.0401, at the temperature of 58°.5, the whole ſolution weighing 1439 grains. He next prepared a ſolution of nitrat of ſoda, of the ſpecific gravity of 1.0401, and found that the ſalt, in 1439 grains of this ſolution, was $\frac{1}{16.901}$ of the whole; therefore $\frac{1439}{16.901} = 85.142$ grains of nitrat of ſoda. Now, the $50.05 - 14 = 36.05$ gr. is the weight of the alkali. The acid, therefore, will be $85.142 - 36.05 = 49.092$ grains; but the acid of 1.5543 weighed 67.179 grains; conſequently $67.179 - 49.092 = 18.087$ will be the water contained in 67.179 of acid, of 1.5543 ſpecific gravity, which is equal to 26.9 *per cent.* Hence 100 parts of nitric acid of 1.5543, conſiſts of 73.1 of real acid, and 26.9 of water.

Dalton has made a number of ſimilar experiments, which ſtrongly confirm the concluſions of Kirwan, the greateſt difference between them being no more than 1.4 *per cent* in the quantity of real acid. The following is a table given by Dalton. The column of real acid is taken from Kirwan, with trifling corrections: in which he has alſo given a column for the quantity of real acid by meaſure, and another ſhewing the number of atoms of acid and water.

Atoms.	Acid *per cent.* by Meaſure.	Acid *per cent.* by Weight.	Specific Gravity.	Boiling Point.
Acid. Water.				
1 + 0	17.5	100	1.75	30°
2 + 1	13.4	82.7	1.62	100
1 + 1	11.2	72.5	1.54	175
	10.2	68.5	1.50	210
	84.7	58.4	1.45	240
1 + 2	77.2	54.4	1.42	248
	71.7	51.2	1.40	247
1 + 3	59.8	44.3	1.35	242
1 + 4	48.6	37.4	1.30	236
1 + 5	40.7	32.3	1.26	232
1 + 6	34.8	28.5	1.22	229
1 + 7	30.5	25.4	1.20	226
1 + 8	27.1	23	1.18	223
1 + 9	24.6	21	1.17	221
1 + 10	22.4	19.3	1.16	220
1 + 11	20.5	17.8	1.15	219
1 + 12	18.9	16.6	1.14	219

The firft column of this table fhews the number of atoms of acid and water, in which it appears, that when the compound is 1 atom of acid to 1 of water, the liquid acid contains 72.5 of real acid, and 27.5 of water by weight, and the fame by meafure will be 112 acid: this laft is governed by the fpecific gravity, which is 1.54. The boiling point of this ftrength being at 175°, it will be feen that the maximum of the boiling point is at 248°; when the liquid acid confifts of 1 atom of real acid to 2 of water, the fpecific gravity being 1.42, and the real acid 54.4 *per cent.* The acid, free from water, if its exiftence in the liquid form be poffible, Mr. Dalton fuppofes would be as volatile as æther. It appears that the acid of 1.42 is the beft ftrength to remain permanent, fince, according to the experiments of this ingenious chemift, the acid and water are fo nearly balanced in their affinities as to evaporate together. The acid or the water will therefore be apt to evaporate, as the real acid or water may be in excefs above this point, which may be denominated the point of mutual faturation.

The acid of this ftrength has very curious properties, on which Dalton makes fome ingenious obfervations. Prouft has ftated, that an acid of the ftrength of 1.48 gives no more effervefcence with tin than it does with fand. When metals, which produce ammonia, are acted upon by nitric acid; thefe, I fuppofe, are fuch as decompofe both the water and acid, taking all the oxygen from both. The metal, under this circumftance, combines with 3 atoms of oxygen, while the nitrogen and the hydrogen form ammonia. If the acid confifted of 1 of real acid to 2 of water, an atom of water would be fet free, which would dilute the remaining acid, and thus facilitate the procefs. If, however, the acid and water were as 2 to 3, then an atom of nitric acid, and an atom of water, would be afforded to the atom of ammonia, forming an atom of nitrat of ammonia. The remaining acid and water would juft be reduced to 1 of acid to 2 of water. At this point, and below it, effervefcence would take place; but in the inftance with 2 of acid to 3 of water, all the products will be difpofed of in forming nitrat of ammonia, and reducing the acid to the ftrength of 1 of acid to 2 of water, during which change no effervefcence will take place. This view of the fubject is very ingenious, and fully explains the phenomena attendant on the oxydation of thofe metals which caufe the formation of ammonia.

The acid of 1 of acid to 3 of water, has no ftriking properties. That which confifts of 1 to 4, Mr. Dalton is of opinion, is that which freezes at — 2° of Fahrenheit. Mr. Dalton, and previous to him, fir Humphrey Davy, have attempted to procure nitric acid in the gafeous form, by combining nitric oxyd (nitrous gas) with oxygen, but their refults have not been attended with fuccefs. This appears to arife from the uncertainty in the combination of nitric oxyd gas with oxygen gas, efpecially when water is not prefent. It appears, from the experiments of Mr. Dalton, that nitric oxyd will combine with oxygen in any proportions between 1.3 and 3.6 of the oxyd to 1 of oxygen. This apparent anomaly to the doctrine of definite proportion is very ingenioufly explained by the above-mentioned chemift. When the nitric oxyd is to oxygen as 3.6 to 1, the oxygen combines with one-half of the nitric oxyd, forming nitric acid, which combines afterwards with the other half to form nitrous acid, or the fuming and coloured nitric acid. When, on the other hand, 1 of oxygen combines with 1.3 of nitrous oxyd, in which the minimum of the latter exifts, a compound is formed, which, according to the opinion of Mr. Dalton, confifts of 1 atom of nitrogen with 3 of oxygen, and which he has denominated the oxynitric acid. The firft of thefe combinations is favoured by ufing a veffel which gives a fhort column of great diameter, and in which the change is quick. The fecond combination, in which the oxygen is in excefs, is facilitated by the change being flow, which is effected by ufing a long tube of fmall diameter. A tube of an intermediate fize being employed when the gafes are 1 of oxygen to 1.8 of nitric oxyd by meafure, the nitric acid will be formed by the union of the two gafes. It is the opinion of this diftinguifhed chemift, that if the gafes, even in exact proportions to form nitric acid, be mixed in a dry veffel, that all the compounds, namely, nitrous acid, nitric acid, and oxynitric acid, may exift, which, when water is introduced, may fo act upon each other, as to form nitric acid. Thefe facts, with the reafoning refulting from the fame, feem to baffle all attempts to obtain nitric acid in a free ftate. Mr. Dalton, after much care and attention, has given the means to determine the component parts of the nitric acid. If, as he feems fully to have eftablifhed, the atom of nitrogen be 5, and the acid be conftituted by 1 atom of nitrogen to 2 of oxygen, the proportions will be 14 of oxygen to 5 of nitrogen, and the weight of the atom of acid will be 19. For the colouring of fuming nitric acid, fee NITROUS *Acid;* fee alfo NITRIC *Oxyd,* and NITROUS *Oxyd.* The combinations of nitric acid with the different faline bafes, are called *nitrats.*

NITRIC, and NITROUS *Acid,* in the *Materia Medica.* The *nitric* acid of the London Pharmacopeia is prepared by mixing *nitrat* of potafh dried and fulphuric acid, of each two pounds, in a glafs retort; and diftilling the nitric acid from a fand-bath, until red vapours are produced; then add an ounce of dried nitrat of potafh, and re-diftil the acid in a fimilar manner. The fpecific gravity of this acid is to that of diftilled water as 1.500 to 1.000. If a piece of lime-ftone be immerfed in a fluid-ounce of it diluted with water, feven drams ought to be diffolved. According to the directions of the Edinburgh Pharmacopeia, any quantity of nitrous acid is put into a retort, and having fitted a receiver, a very gentle heat is applied until the reddeft part fhall have paffed over, and the acid which remains in the retort have become nitric acid. The *nitrous* acid of the Edinburgh Pharmacopeia is prepared by pouring fixteen ounces of fulphuric acid upon two pounds of bruifed nitrat of potafh in a glafs retort, and diftilling from a fand-bath, with a gradually augmented heat, until the iron pot becomes obfcurely red-hot. The fpecific gravity of this acid is to that of diftilled water as 1.550 to 1.000. The Dublin Pharmacopeia orders fix pounds of nitrat of kali to be mixed with four pounds by weight of fulphuric acid, and then diftilled until the refidue becomes dry. The fpecific gravity of this acid is to that of diftilled water as 1.500 to 1.000.

In performing thefe operations, it is advifable to ufe Woulfe's apparatus, or a range of two or three globular receivers, the laft of which fhould contain a fmall portion of water. In order to prevent the nitrous oxyd from combining with the condenfed acid in the receiver, deepening its colour, and giving it that form which conftitutes nitrous acid, the London College orders a large portion of fulphuric acid to be employed, which ferves to contribute a fufficient portion of water for preferving the conftitution of the nitric acid; for, although a large proportion of this acid be obtained by following the directions of the London formula, yet it is actually weaker than that which is obtained either by the Edinburgh or the Dublin proceffes. The Edinburgh College orders the acid to be kept in this form; and as a medical agent it anfwers the fame purpofes as the colourlefs acid; for, when both are diluted with water, they have

the fame appearance, and are brought to the fame ftate, the addition of the water expelling completely the nitrous oxyd, which is loofely united with the nitric acid to form the nitrous. The quantity of acid obtained is about half the weight of the nitrat employed: and the refidue is a white, fpongy, faline cake of fulphat of potafh, with an excefs of fulphuric acid, which may be diffolved out of the retort by hot water. By the London procefs, the nitric acid is at firft obtained tolerably free from nitrous oxyd; but in general the re-diftillation will be found neceffary. In the expulfion of the nitric oxyd, to change the nitrous into nitric acid, according to the directions of the Edinburgh College, a portion of the acid is carried over with the gas, as nitrous acid vapour: this fhould not be wafted, but be condenfed by a fmall portion of water being put into the receiver, and thus form a diluted acid. Mr. Murray (Mat. Med.) juftly obferves, that the heat of a water-bath is beft adapted for this operation, being fufficient for the purpofe, and not too high to produce the decompofition of the acid. A completely colourlefs acid, however, is not obtained, unlefs the acid be re-diftilled from a fmall portion of black oxyd of manganefe; but this is not neceffary for medical purpofes. The contaminations of nitric acid by muriatic or fulphuric acid do not affect its medicinal virtues.

Nitrous acid, as the term is underftood in the Edinburgh Pharmacopeia, is a yellow or orange-coloured fluid, emitting, when expofed to the air, deep orange-coloured extremely fuffocating fumes With regard to its chemical affinities and other qualities, it agrees in every refpect with nitric acid. It confifts of nitric oxyd loofely combined with nitric acid and water.

Nitric acid is a colourlefs, or very pale yellow, limpid fluid, emitting, when expofed to the air, white fuffocating vapours, and poffeffing ftrong acid properties. It is highly corrofive, and tinges the fkin yellow, which remains till the epidermis is peeled off. It unites with water in every proportion, and while mixing heat is evolved. See the articles NITRIC and NITROUS *Acid*, fupra.

Strong fluid nitric acid is ufed only for pharmaceutical purpofes; except when extricated in the form of vapour, it is employed for deftroying contagion. It is lefs powerful than the oxymuriatic acid, but is more generally ufeful, as it can be extricated in the chambers of the fick without proving deleterious to animal life. For this purpofe, f℥ij of fulphuric acid may be poured over ℥iv of coarfely powdered nitre in a china cup, and placed in a pipkin of hot fand. This quantity is fufficient for fumigating a room that is ten feet fquare; and where a larger portion is required, it is more advifable to multiply the number of pipkins than to put a larger quantity of the materials into one veffel. The officinal preparations of nitric acid are the following, *viz.* Acidum nitricum dilutum, L.E.D.; Oxydum antimonii, L.; Argenti nitras, L. D.; Liquor ferri alkalini, L.; Ung. hydrargyri nitratis, L. E. D.; Hydrargyri nitricum oxydum, L.; Spiritus ætheris nitrici, L. E. D.; Unguentum acidi nitrofi, E. D.

The diluted nitric acid, L., is prepared by mixing a fluid-ounce of nitric acid with nine fluid-ounces of diftilled water. For that of E. take equal weights of nitrous acid and mix them, avoiding the noxious vapours. For that of D. take of nitrous acid and diftilled water of each one pound. The fpecific gravity of this mixture is to that of diftilled water as 1280 to 1000. When the diluted acid is prepared according to the directions of the London College, f℥i contains about grs. x of nitric acid, of 1.500 fpecific gravity, while the fame meafure of the fame acid, prepared after the Edinburgh and Dublin, and the former London formulæ, contains grs. xxxv of the fame acid; a difference, which, as it may lead to errors in practice, is to be regretted.

Nitric acid is tonic and antifeptic. When largely diluted with water, it forms an agreeable and ufeful beverage in fevers, particularly of the typhoid type. In larger dofes, lefs diluted, it has been adminiftered with effect in chronic hepatitis, even when dropfy has fupervened; and it has alfo been ferviceable in reftraining violent ficknefs, in dyfpepfia, afthma, and the greater number of cachexiæ. From obferfervations of Mr. Scott, publifhed at Bombay in 1796, this acid excited attention as a remedy for fyphilis; but after the moft ample trials, by almoft every practitioner of eminence in the country, its antifyphilitic powers have not been found to correfpond to the accounts of thofe tranfmitted from India. Although it gives a temporary check to the progrefs of the difeafe, it does not permanently remove the fymptoms; and, as Mr. Pearfon juftly obferves, it would by no means be warrantable to fubftitute the nitrous (or nitric) acid in the place of mercury, for the cure of venereal complaints. It has been found, however, of confiderable fervice when given at the fame time with mercury, in old obftinate ulcerations of the legs, although no venereal taint could be fufpected; and it is employed with benefit as a local ftimulant in the form of lotion, in the proportion of f℥ij of the acid to oj of water, to fœtid ulcers, attended with a thin ichorous difcharge, and in caries of the bones. In India it is fometimes ufed in the form of a bath, and in this ftate produces the fame effects as when it is taken internally. The dofe of the diluted acid is from m x to m xxx in f℥iij of water, given three or four times a day. Its officinal preparations are, Aceti hydrargyri, E. D.; Submurias hydrargyri præcipitatus, E. D.; Submurias hydrargyri ammoniatus, D.; Oxydum hydrargyri cinereum, E. D.; Oxydum hydrargyri rubrum, E. D. See MERCURY. Thomfon's Lond. Difpenfatory, 1811.

NITRIC *Oxyd*, in *Chemiftry*. This fubftance, like the nitric acid, is a compound of nitrogen with oxygen: the former being formed of 1 atom of nitrogen to 2 of oxygen, the latter 1 to 1.

Several of the metals, as filver, mercury, and copper, when added to the nitric acid, deprive it of 1 atom of oxygen only. The remainder, which is 1 to 1, efcapes in the form of gas. This gas has been formerly called nitrous gas; but, according to the prefent ftate of chemical nomenclature, it is called nitric oxyd.

To procure nitric oxyd, introduce fmall bits of copper into a gas bottle, or a fmall retort, upon which pour nitric acid of the fpecific gravity 1.2. Let the procefs go on a little, the mouth of the retort being under water, or mercury, before the gas is collected. This ferves to difplace the air of the retort. The gas, which is now obtained, will be colourlefs as common air. In this procefs, an atom of copper decompofes two atoms of nitric acid, taking an atom from each to form the fecond oxyd of copper. This oxyd then combines with two other atoms of acid, to form nitrat of copper. The two atoms of nitric oxyd, refulting from the decompofed acid, would be abforbed by the remaining acid, if a fufficient quantity were prefent; by which it would acquire, firft, a yellow colour; a deep orange, as it increafes; next, a green; and ultimately, a blueifh tint. For the better obfervance of thefe fhades of colour, filver fhould be employed inftead of copper; fince the folutions of copper in any acid are of green colour. When, however, the excefs of acid is not great in producing nitric oxyd, a great proportion of this gas is evolved. For common pur-

poses, it may be collected over water, which absorbs only about $\frac{1}{20}$th of its bulk: on some occasions, however, it is necessary to collect it over mercury.

Nitric oxyd may be separated from other gases, by means of solutions of iron with the black oxyd. The liquid, by agitation, soon absorbs all the nitric oxyd, without affecting any other gas that might exist with it. This furnishes an easy method of ascertaining the purity of nitric oxyd. The absorbed gas may be separated unchanged by heat.

When the nitric oxyd is mixed with oxygen, or is brought in contact with the atmosphere, red fumes immediately appear, which are of greater density than common air. This is called nitrous acid gas.

The specific gravity of nitric oxyd is to common air, according to Kirwan, as 1 to 1.19; but Davy, who is nearer the truth, makes it 1.102. If hydrogen be equal to 1, and 100 cubic inches weigh 2.5 grains, then the nitric oxyd will be 13, and 100 cubic inches of it will weigh 32.5 grains.

When a lighted taper, or sulphur in a state of inflammation, are immersed in this gas, the flame becomes extinguished; but phosphorus and charcoal, when once kindled, burn in it, and consequently deprive it of its oxygen.

Several of the metals, such as arsenic and zinc, when heated in this gas, deprive it of its oxygen; the residual gas being nitrogen.

Other bodies take away only part of its oxygen: of these are the alkaline sulphurets, the muriatic solution of tin, and several of the sulphats. For these facts we are indebted to sir Humphrey Davy. The resulting gas is the nitrous oxyd, which is composed, according to Dalton, of one atom of oxygen to two of nitrogen. In this process, an atom of nitric oxyd gas gives up an atom of oxygen, which combines with the decomposing body; while the deserted atom of nitrogen combines with an atom of nitrous gas, forming nitrous oxyd. This most clearly shews why the atom of nitrous oxyd should be heavier than an atom of nitric oxyd. The latter atom is constituted by 1 to $1 = 5 + 7 = 12$; the former of 1 of oxygen to 2 of nitrogen, or $7 + 2 \times 5 = 17$. Sir Humphrey Davy, notwithstanding this corroborating fact, considers nitrous oxyd as 1 of oxygen to 1 of nitrogen; by doing which, the nitric acid is made to consist of 1 of nitrogen to 5 of oxygen; a thing very improbable between two bodies having so little affinity for each other.

When nitric oxyd is acted upon by electricity, an atom of oxygen is liberated from one atom of the gas, and given to another, till the whole is divided into nitric acid and nitrogen. In other words, one-half of the gas gives its oxygen to the other half. By this change, if the original volume be 1, the resulting volume will be $\frac{1}{2} \times \frac{13}{12.125} = \frac{13}{24\frac{1}{4}}$, a little more than half.

When nitric oxyd is mixed with hydrogen, it does not explode by the electric spark. It is, however, said to detonate, when passed through a red-hot porcelain tube; the result being water and nitrogen. The relative volume of these gases, to produce this result, will be 13 of hydrogen and 12 of nitrogen.

We are indebted to Dr. Henry for the fact of nitric oxyd being decomposed by ammonia. For this purpose, the two gases are to be put into the strong tube, called Volta's eudiometer, and the electric spark passed through them. When the nitric oxyd is in excess, the result is nitrogen, water, and a little nitric acid; when the ammonia predominates, then nitrogen, water, and hydrogen are produced.

From the great facility with which the nitric oxyd combines with oxygen, it has been employed to ascertain the quantity of oxygen mixed with other gases. There is, however, some uncertainty in this method, in consequence of several compounds being formed by oxygen and nitric oxyd. Dalton recommends an excess of the latter to be used, in order to prevent the ambiguity above mentioned, and afterwards to take up the excess with a solution of the green sulphat of iron.

When nitric oxyd is mixed with oxymuriatic acid gas, a sudden decrease of volume takes place, from the muriatic acid and nitric acid being formed, both of which become liquid. This effect, however, does not take place, if the gases be perfectly dry, and the vessels free from moisture.

Since an atom of nitric oxyd consists of 1 of nitrogen to 1 of oxygen, the weight of its atom will be $5 + 7 = 12$; the nitric acid, being 1 of nitrogen to 2 of oxygen, will be $5 + 2 \times 7 = 17$: hence the proportions of oxygen and nitric oxyd to form nitric acid will be 7 to 12. In mixing this with other gases, where mutual action takes place, the proportion by weight will be as the weights of their atoms. Their proportions by volume will be obtained, by multiplying the ratio of their weights by the united ratio of their specific gravities: the latter ratio will be easily expressed, by making the specific gravity of hydrogen gas unity. If, for instance, nitric oxyd be mixed with hydrogen, to be passed through a red-hot porcelain tube, the proportion by weight will be 12 of the oxyd to 1 of hydrogen, the relative weights of their atoms, and $\frac{12}{1} \times \frac{1}{13} = \frac{12}{13}$, or 12 of nitric oxyd by measure to 13 of hydrogen. Ammonia and nitric oxyd will be $\frac{6}{12} \times \frac{13}{7.5} = \frac{13}{15}$, or 13 by volume of ammonia to 15 of nitric acid.

Oblique arches

OBLIQUE *Arches*. Whenever high roads run oblique to the courſe of any river, rivulet, drain, or canal, neceſſary to be paſſed over by a bridge, the direction of the *former* is generally varied ſo as to be rectangular to the courſe of the *latter*; unleſs in ſmall ſtreams, over which, when their courſe is not made to ſuit the road, there are ſeveral inſtances of the conſtruction of what are uſually termed *ſkew-bridges*. Theſe, with the exceptions which will be afterwards mentioned, have been built in the uſual manner of laying each courſe of ſtones or bricks of the arch parallel to the line of the abutment, and bevelling off their ends, on each exterior face of the arch, in a line correſpondent with the intended direction of the road over the bridge, as ſhewn in *fig*. 1. In this figure it is obvious, that ſo far as one abutment of the bridge extends beyond the rectangular line from the extremity of the other, ſuch a portion of arch, *viz*. *a b*, has no ſupport from the oppoſite abutment, unleſs what may be derived from the interlapping or breaking joint of the bricks or ſtones compoſing the arch; and from the goodneſs of the mortar, tending to cement them into one maſs: therefore, accordingly as theſe circumſtances have operated, and alſo in proportion to the ſmallneſs of the arch, in which the parapet covers a larger ratio of the unſupported part of it, the ſkew-bridges thus built have ſtood more or leſs firm, with an obliquity of 10° to 15° from a rectangle with the abutment; and in many inſtances, that portion of the arch has cracked or given way. Theſe circumſtances have prevented cautious builders from adopting this method; and induced them, in a few inſtances, to build the arch ſquare to its abutments, and run the parapets oblique, to coincide with the line of road; leaving alternate triangles of the arch on the outſide, which has a diſagreeable appearance, and has ſeldom been uſed; therefore, in general, unleſs the courſes of ſtreams or canals were made rectangular to the road, the line of the latter has been altered ſo as to admit of a direct paſſage over the water, which upon high roads, when not curved for a conſiderable diſtance, is inconvenient if not dangerous; and particularly ſo to travellers in the night time; from which cauſe the ſkew-bridges deſcribed were, with all their imperfections, occaſionally had recourſe to; and the writer of this article has never heard of any alteration in their form prior to the year 1787. At this time he had the direction of the county of Kildare canal, a branch from the Grand Canal of Ireland to the town of Naas.

In the courſe of conducting the work, ſeveral of the directors of that canal were anxious to have the line of the roads unvaried; therefore our author was led to conſider whether the uſual imperfect method could not be ſet aſide, by the ſubſtitution of one on ſound principles; and it then occurred that its leading feature muſt be, that the joints of the voiſſoirs, whether of brick or ſtone, ſhould be rectangular with the face of the oblique arch, in place of parallel with its abutment; and, conſequently, the bridges over the county of Kildare canal were made to ſuit the line of road, although the obliquity of one of them was carried to an extent beyond what he deemed eligible in practice, as will appear from the obſervations made on Finlay bridge, near the town of Naas, which deviated 51° from a rectangle with the canal, and conſequently formed the acute angle of 39° with its abutments. Its ſpan, in that oblique direction, was 25 feet, and its pitch 5 feet 6 inches, or nearly $\frac{2}{9}$ths of its ſpan. The plan of this bridge is given in *fig*. 2, and in *fig*. 3. the elevation of its arch, more to ſhew the extent to which it has been carried than to recommend its propriety; principally becauſe of the difficulty of forming the voiſſoirs of the impoſt courſe; and alſo, becauſe to retain the ſame breadth of roadway, the bridge muſt be enlarged as the ſecant of the angle of obliquity is to radius, *viz*. as *a b* to *a c*, which in the preſent inſtance is as 159° to 100°; likewiſe, for general purpoſes, one breaſt-wall on each ſide muſt be conſiderably extended to coincide with its oppoſite one, or nearly ſo; alſo, the impoſt courſe muſt be ſerrated, as ſhewn in the explanation of *fig*. 8; and as the lines, in which the beds of the voiſſoirs run, are obviouſly ſpiral lines, it follows that the ſoffit of each ſtone muſt be curved in that direction, and likewiſe it muſt be twiſted in its ſommering, which, although not inſuperable difficulties, are ſo in ſuch a degree, as, combined with the indented form of the impoſt, to render it adviſable to uſe bricks, both for the impoſt and arch, or at moſt to be contented with the uſe of ſtone only for the quoins and their neceſſary impoſts, in the forming of which intelligent ſtone-cutters will be requiſite, as will appear from *fig*. 3, where a part both of the intrados and extrados of the arch is ſhewn as viewed from an infinite diſtance, not being reduced in perſpective. It is there apparent that the head of each voiſſoir on that ſide of the arch where its face forms an acute angle with its abutment, muſt make an obtuſe angle with its ſoffit, decreaſing in their approach to the crown of the arch, and thenceforward becoming acute, and increaſing as they advance to the other impoſt, where the face of the arch forms an obtuſe angle with its abutment; therefore the different ſides of the ſame voiſſoir muſt form different angles of elevation or depreſſion from the rectangle with its head.

A geometric mode of forming each voiſſoir would be complicated, as will appear from the following diagrams, *viz*. let the lines *a b*, *b d*, and *d c*, in the diagram, *fig*. 4, include a portion of the ſpace to be covered by the arch, *a b* and *c d* being the lines of its abutments; then let the diſtance intercepted between *d b*, and its parallel line *x y*, which likewiſe extends between the abutments, expreſs the extent to be covered by any given number of the voiſſoirs forming that portion of the ſoffit, ſuppoſe every alternate one:—let the circular arcs raiſed upon each of theſe lines expreſs the elevation of the arch at each place reſpectively; *u* and *v* will then ſhew the crowns of their ſoffits. The line *t t*, drawn at right angles with the face of the arch, and with its reſpective extremities equidiſtant from the points *u* and *v*, will repreſent a joint on the ſoffit, which muſt neceſſarily be horizontal at its extremities; becauſe equidiſtant from the crown of each arc, although on alternate ſides; then if equal ſpaces on each ſide of the point, *t*, be ſet off on each reſpective arc, it will ſhew upon each where the joints of the ſame voiſſoirs will coincide. Four of theſe ſpaces in the

arc *d u b*, which reprefents the front of the arch, reach from *t* to *d*, *viz.* to the abutment on the fide, where it forms an obtufe angle with that front, whilft the fame number of fimilar fpaces *in the like direction* extend only from *t* to 4, in the arc *x v y*, reprefenting the internal end or extreme extent of the voiffoirs feen on the face of the arch. The fame circumftances are reverfed on the fide where the front forms an acute angle with the abutment, as fhewn by the fimilar references on the other fide of *t t*: confequently the joint 4, in front of the arch, will fall into the impoft at *y* on the rear line. The radiating lines rifing above each arc, drawn from their refpective centres *b* and *g*, fhew the twift or different fommering lines at each extremity of the fame joint: the difference of thefe divergencies would be more clearly feen by exhibiting fimilar lines upon the arc *r v s*, which reprefents that of *x v y*, upon the fame level as the front arc *d u b*, preferving an equal lateral diftance between them, which as it may be eafily conceived is left undone, becaufe they would interfere with the lines requifite for the further explanation of the fubject. The points, *r* and *s*, upon the laft defcribed arc, correfpond with *x* and *y* upon that for which it is fubftituted, every remaining letter or figure of reference being the fame in both.

The vertical fpaces on the acute fide of the arch intercepted between 4 *s*, 3 3, &c. until they become horizontal at *t*, fhew the proportionate depreffion of the foffit of the joints they reprefent; and on the other fide, *d* to 4, on the lower dotted arc; 3 3, &c. fhew the rife on each voiffoir abutting on thefe points. The horizontal bafe between the extremities of each joint is fhewn by the lines *d n*, *z m*, *k k*, &c. which extend between the chords *d b* and *x y*, from the points found by the interfection of the ordinates from the correfpondent numbers of their refpective curves. The horizontal bafe, *k k*, is the only one that is rectangular to the chord of the arc; all the other bafes diverging towards that abutment which forms an obtufe angle with the arch, and increafing towards the haunches. At the firft view of the diagram they appear to diverge both ways, but on inveftigation it will be feen that the letter *n*, on the fide of the acute angle, has reference to the front arc, and on the other fide refers to that reprefenting the inner end of each joint. From thefe data we fhall proceed to fhew the longitudinal fection or fide elevation of a voiffoir at *t t*, and other parts of the arch: *k k*, *fig* 5, correfpondent with *k k*, *fig*. 4. but on a larger fcale, exprefs the bafe of the voiffoir, and *k r*, its height of face, or its width of bed, which latter may be affumed to be fimilar in the others, *viz.* *d i*, *fig*. 6. and 4 *i* *fig*. 7. The rife of the curve in the foffit between *k* and *k*, muft obvioufly be equal to the difference between the ordinates *t k* and *u e*, *fig*. 4, becaufe the crown of the arch fhewn by the line *v u*, muft be interfected at half-way between *t*, *t*, the extremes of the voiffoir; one end of the ftone being on that fide of the crown defcending to the left, and the other extremity equidiftant on the fide defcending to the right. The breaft-wall is fhewn rifing rectangular from this voiffoir. *Fig*. 6. upon the principles already explained, fhews on the fide where the front line of the arch makes an obtufe angle with its abutment, the voiffoir rifing from the fpringing point at *d* to 4, on the pofterior arc which correfponds with its inner extremity; and *fig*. 7. exhibits, on the fide where the front is acute with its abutment, the bed of a voiffoir commencing at 4, on the front arc *d u b*, and defcending to the abutment at *s*, on the arc reprefenting the other extremity. By thefe diagrams it appears, that under equal widths of bed the fpace between the intrados and extrados increafes upon the face of the arch as the haunches of the arch are approached: therefore the rough blocks for the voiffoirs muft be increafed in their breadth of face to allow for the further divergency of their fommering lines, arifing from their height of face, or difference between intrados and extrados, being increafed as the fecants of their angles of deviation from a rectangle with a line between each extremity of their foffit: *viz.* as *d z* is to *d i*, *fig*. 6, or 4 *r* to 4 *i* in *fig*. 7. And if the twift of the fommering lines be attended to, the long voiffoirs muft have a ftill greater width of block between their beds than the fhort ones: therefore, previoufly to the fitting each ftone to its individual place, as the work advances nothing more can eafily be done than giving due allowance to the firft of thefe variations, which will be fufficient in practice where the arch, excepting its quoins, is formed of brick; becaufe the facility of making the brick fheeting break joint with the ftone voiffoirs of the face, will render it unneceffary to twift the beds of the latter, and with the precaution mentioned, and the neceffary aid of a bevil rule with a moveable joint, and its long arm formed of fhort jointed links to fuit the curve of the foffit, in the direction of each ftone and towards the haunches on each joint of it, the operations of fitting each voiffoir to its place will not be difficult.

Fig. 6. fufficiently fhews the danger of the breaft or face-wall fliding outwards on the acute angles of the foffit; therefore, when the obliquity of the arch is carried near to that of Finlay bridge, which thefe diagrams reprefent, either the breaft-wall fhould be curved, where it forms an obtufe angle with the abutment, or the voiffoir fhould have offsets, which may be of the breadth of a brick, if the wall be built of that material, to form a ftop to its flipping forward, as fhewn by the dotted lines under it in *fig*. 6.

We fhall now point out fome anomalies from the leading principle, which are neceffary to be adverted to, for a due knowledge of the mode of conftructing oblique bridges.

A femicircular arch obvioufly covers a femi-cylinder; and a leffer portion of the arc of a circle will confequently cover a fimilar portion of it. If it be fuppofed, in either inftance, that the cylindric fegment, lying horizontally on its plane, with its axis in the direction of its abutments, is longer than neceffary for the road-way over it, in any given oblique direction; we then, to obtain an oblique arch, have only to conceive the convex face of the cylindric fegment to be cut down between two parallel vertical planes, in the direction required. But this arch, from the nature of cylindric fections, will be elliptic; which is not fo eligible in practice, becaufe of its quicker rife at the haunches of the arch, the inconveniencies of which have already been explained; and they obvioufly militate not only againft the elliptic form, but alfo any near approach to a femicircle.

We have obferved that the leading principle of thefe oblique arches is, that each courfe of voiffoir fhould run rectangular to the face of the arch. This, however, muft be taken in a limited fenfe; becaufe if the fheeting, or bed of the arch, were unfolded, or laid into a plane, its faces on the two extremities, bounding the paffage over it, would not be ftraight lines parallel to each other, like the parapet walls; but would form two curved lines, each convex where the line of the arch is acute with the abutment, and concave when it approaches the other fide where the intercepted angle is obtufe. This irregularity neceffarily arifes from the circumftance, that each front line of the fheeting, *m g p*, and *n h q*, *fig*. 8, in its courfe from the crown of the arch, in a direction oblique to *g b*, (the axis of the vault tranfverfe to the abutments,) muft not, in its fpiral gyration along the furface of the cylindric fegment on each fide of

g h, advance through equal ratios of the axis, in equal portions of the arc, but ſimply as the reſpective horizontal baſes of theſe portions: therefore its deviation from a line rectangular with the axis becomes progreſſively leſs in its approach to each abutment.

The greater or leſs curvature of the two faces of the arch, when drawn out as a plane, muſt depend on the greater or leſs pitch of the arch, as ſhewn in *fig.* 8; where *r s* and *t d* are the abutments of the bridge, and, conſequently, *r s d t* the baſe of the arch. The angle of obliquity is here 51°, as in the preceding diagram: the line *g h* paſſes along the crown of it; and the curved lines, *g m* and *h n*, terminated by the line *m n*, exhibit half the arch of Finlay bridge, drawn out as a horizontal plane; *m n* and *t d* being parallel to, and rectangular from each other; and their diſtances from the crown of the arch, *g h*, in their reſpective lines, *g m*, *h n*, and *g t*, *h d*, being in one the length of the ſemi-arc, and the other that of its baſe. On the other ſide of the line *g h*, the curved lines, *g p* and *h q*, connected by the right line *p q*, ſhew the form of half a ſemicircular arch of the ſame baſe, drawn out into a plane. In both exhibitions, it is clear that lines drawn perpendicular to different parts of the face of the arch, to ſerve as guide-lines to the joints of the ſoffit, would in one part converge to each other, and form triangles; and in the other part, where the face-line extended on a plane is concave, would diverge, ſo as, in both inſtances, to occaſion great irregularity and difficulty in cloſing of the arch; which actually takes place in practice, unleſs due attention be paid to its leading principles, which have been pointed out in the explanation of *fig.* 4, ſo far as that diagram enabled them to be; which, although not to the extent requiſite for the conſtruction of the arch, may be made perfectly comprehenſible to any practical man, by attention to the following inſtructions, *viz.* after the centres, which are placed parallel to the face of the arch, and diagonally to its abutment, are put up, and covered with their plank-ſheeting, carefully ſet off their bounding-lines, *m p* and *q n*, as in any other arch; ſo that every part of theſe face-lines ſhall be perpendicular to, or directly under, a horizontal line ſtretched from *r* to *t*, or from *s* to *d*, upon the level of the crown of the arch. Then, equidiſtant from each abutment, *viz.* along the crown of the arch, ſtrike the line *g h*, which will of courſe be a ſtraight line. Divide it into any given number of equal parts: if very oblique, ten or twelve may be ſufficient; and in arches of ſmall obliquity, a few diviſions will do. The preſent diagram (*fig.* 8.) is more oblique than will probably be adopted; but the ſcale being minute, the line *g h* is divided into only ſix parts, as the purpoſe of explanation will be equally well attained.

The figures 1, 2, 3, &c. in ſucceſſion from *h* to *g*, ſhew the diviſions on that line; and *a*, *b*, *c*, &c. exhibit correſpondent ſpaces cloſe to each abutment. Theſe diviſions being made, ſet out, on the ſheeting, ſo many parallel lines to the outer faces, *m g p*, and *n h g*, *viz.* *a* 1 *a*, *b* 2 *b*, &c.: *k* 1 repreſents a line of joint near the crown of the arch, and rectangular to its face; which commencing at the diſtance of *h k*, will interſect *h g*, the line of the crown, at the diſtance of *h* 1, from the face of the arch; and will repreſent half the line, *t t*, in diagram, *fig.* 4.

By the theory laid down for theſe arches, the joints on their ſoffit are to run parallel to each other; or rather they are to interſect equal portions of parallel equidiſtant arcs, ſtanding in a line oblique to their common axis. This end may obviouſly be obtained, by ſetting off on each face of the arch, and on each of the parallel equidiſtant lines, *a* 1 *a*, *b* 2 *b*, &c. ſpaces ſimilar to *h k*, in ſucceſſion after each other from the points *h* 1, 2, 3, 4, 5, and *g*, towards each abutment; and then to mark upon the ſheeting ſtrong lines, to direct the courſe of the joints, ſuch as ſhewn by *k* 1. 1 *u*, *u v*, &c. which will form a polygonic curve, more or leſs approaching to a regular curve, according to the obliquity of the arch, and its approximation to a ſemicircle, and the number of diviſions between *h* and *g*. The horizontal baſes of the ſoffit joints near the abutments, on each ſide of the arch, are, as ſhewn in *fig.* 4, inclined from the line of the face towards that abutment which forms with it an *obtuſe* internal angle: notwithſtanding which, theſe joints, when drawn on the plane of the ſheeting, deviate from the rectangle, with its face line *towards* the abutment which forms an *acute* internal angle with the line of the arch, and *from* the abutment on the oppoſite ſide, as ſhewn by thoſe lines in *fig.* 8.

Theſe excentricities, although they render it difficult to form all the voiſſoirs prior to the commencement of the arch, are eaſily got over by forming them in ſucceſſion, as deſcribed.

As the lines, *a* 1 *a*, *b* 2 *b*, &c. over the curve of the arch will be rather troubleſome to form correctly, the beſt mode in practice will be to mark off on each face, and each ſide of the arch, a continuation of the ſpaces, *q i* and *h k*, towards each abutment. Then as the progreſſive correſpondent points from *g* and *h*, *viz.* *i f*, *o l*, &c. will have right lines between them, ſtraight chalk-lines can eaſily be ſtruck; and when the ſpaces, *h* 1, *h* 2, &c. are ſet off upon each of them, the interſecting points ſimilar to *u*, *v*, *x*, &c. will be found the ſame as upon the lines *a* 1 *a*, *b* 2 *b*, which, therefore, have no occaſion to be formed.

Had the number of diviſions on the line *h q* been greater, the curvature of the joint lines would have appeared more material on that ſide of the diagram, exhibiting a ſemicircular arch expanded; but on the other ſide, where the arch is of the flat pitch deſcribed, but with great obliquity, the deviation from right lines is ſo much leſs ſo, that in brick-work the joint-lines may eaſily be followed. In ſimilar arcs of moderate obliquity, the divergency is of courſe leſs; but yet it will, unleſs the arch approach within about 20° of a rectangle with its abutments, be ſufficient to occaſion conſiderable irregularity, if the joint-lines be continued acroſs, rectangular from either face.

We had frequent opportunities of ſeeing, for ſeveral years after it was built, the bridge from which moſt of the diagrams have been drawn, and never obſerved any crack in it; but yet from the uncertainty of obtaining careful and intelligent overſeers, and good materials, and likewiſe becauſe of the greater expence, and not having inveſtigated the ſubject in all its bearings, ſo as to lay down ſufficiently plain inſtructions, we did not then, in ſeveral bridges over the Grand Canal of Ireland, which we directed to be built obliquely, and in other bridges, ſubſequently, over wide drains in the Eaſt Riding of Yorkſhire, venture to exceed 40° of obliquity, and rarely 30°, although the angle of interſection of the road and water was generally more conſiderable. It is clearly evident that this extent of angle would often be highly uſeful, as it would rarely leave much to be made up by the deviation of the road from its uſual direction. The wing-walls of Finlay bridge were curved one more than the other on the ſame ſide, to give a paſſage along each bank of the canal; but where not over a canal, if the line of direction of the road coincide with that of the bridge, the wing-walls may terminate more nearly ſquare with the road, or completely ſo, as in *fig.* 9, which ſhews one of theſe bridges under an obliquity of about 40°, with the *arch uncloſed*, ſo as to ſhew the wood ſheeting ſupporting

it, and the mode of clofing it without unequal preffure on each fide of the centres.

From what has already been explained, it neceffarily follows that each impoft of the arch, in place of being fimply fommered to the radiating line of the incumbent curve, muft alfo, as appears in *fig.* 3, be ferrated (as fhewn between *e* and *e*, *fig.* 8.) to fuit the adjoining bed of the ftones, or bricks, forming the arch.

The cafual utility of thefe arches is obvious, and the theoretic and practical mode of forming them has been explained to fuch extent, as to make the procefs eafy to any intelligent mafon. Since the period we have mentioned, the plan has in a few inftances been followed; and the fame idea may have occurred to others, although we have never heard of it.

The principal ufe of thefe bridges will be where lines of projected canals interfect high roads with obliquity; in which cafe, the road, if curved for a fufficient extent to fall in with a rectangular paffage over the canal in fo gentle a manner as it ought, would require a confiderable length of double curve, *viz.* alternately outwards and inwards on one fide, or both, accordingly as the bridge might be placed, an inftance of the latter of which is fhewn in fketch N° 10. Under this predicament, where the land is valuable, or houfes interfere to interrupt the change of road, it may often be found advantageous, becaufe more economical to incur the increafe of expence attendant on the conftruction of an oblique bridge; which, under moderate angles of departure from the right line acrofs, is not very material; and where it becomes fo, will fometimes be greatly inferior to the advantages acquired by it. We have been indebted for the preceding article to — Chapman, efq. a well-known and ingenious engineer, to whom we have already referred under the article CANAL.

Ochre

OCHRE, in the *Arts*, a yellow powder of an earthy appearance. It in general conſiſts of ſome earth, as lime or clay, combined with a ſub-ſalt or oxyd of iron.

The oxyd of iron in this ſubſtance is moſtly combined with either the ſulphuric or carbonic acids, and in general is derived from the decompoſition of ſuper-ſulphuret of iron. By expoſure to the air and moiſture, the latter ſubſtance is converted into ſulphuret of iron. This ſalt, by expoſure to the oxygen of the atmoſphere, ſoon reſolves itſelf into two ſalts, namely, the ſuper-oxyſulphat of iron and the ſub-oxyſulphat. The latter, being inſoluble, is precipitated, forming a yellow depoſit, frequently ſeen in ſuch chalybeate ſprings as reſult from the decompoſition of pyrites. This yellow precipitate penetrates the earth and tinges it with the ſame colour, but more dilute. The mixture conſtitutes a ſpecies of ochre. When the ſoil, with which the ſubſalt combines, conſiſts of certain proportions of lime and alumine, free from ſtones or other heterogeneous matter, the ochre is more valuable.

Thoſe chalybeate waters which contain the ſuper-carbonat of iron, and which are frequently found, are capable of forming ochre, but of a different quality from the laſt. The carbonat held in the water is ſuper-carbonat with the black oxyd of iron. By expoſure to the air an atom of carbonic acid eſcapes, the oxyd takes another atom of oxygen from the atmoſphere, and is precipitated with the other atom of carbonic acid in the form of oxycarbonat, which is in the form of an inſoluble powder of a yellow colour. This ochre is of a deeper yellow than that derived from the ſub-oxyſulphat. Its colour may be converted into a beautiful brown by applying a heat to it, ſufficient to expel its carbonic acid, leaving behind the ſecond oxyd of iron. The heat of boiling water is ſufficient for this purpoſe. This ochre, ſo changed, has moſt of the properties of umber. The ſub-ſulphat does not ſo readily aſſume the brown colour, on account of the greater heat required to expel its acid.

Artificial ochres may be prepared of equal, and perhaps of ſuperior quality to thoſe in nature. The ſulphat of iron in the manufacture of this article, previous to its cryſtallization, is partly in the ſtate of oxyſulphat, and becomes wholly ſo by long expoſure to the air. As it remains in this ſituation it will gradually reſolve itſelf into the ſuper oxyſulphat and the ſub-oxyſulphat. The latter falls to the bottom of the veſſel in the form of a yellow powder, which, when waſhed and dried, conſtitutes a beautiful colour.

When carbonat of potaſh is added to the ſuper-oxyſulphat, the carbonat of iron will be formed, which will precipitate in the ſtate of a yellow powder. This powder, when waſhed, and the water evaporated, conſtitutes an ochre which is a little deeper in colour than the laſt. The heat of boiling water drives off the carbonic acid, leaving the oxyd of an agreeable brown colour.

Ochre, in *Agriculture*, a ſort of oxyd or calx of iron, which is frequently met with in ſome ſorts of ſoil. The author of Phytologia ſtates, that red ochre may in ſome caſes be favourable to vegetation, though it has generally been ſuppoſed prejudicial to it.

It is, however, ſtated by Mr. Nicol, that the moſt untoward of all ſoils, for the produce of timber in high perfection, is an irony till of little depth, lying on a retentive ſubſoil, which upholds a poiſonous ochry water, and which ſtagnates on the ſurface, or remains latent in the body of the ſoil, which is the paſture of the roots, contracting the mouths of the fibres, contaminating the juices, and finally operating to the deſtruction of the tree, by poiſoning it, and haſtening its diſſolution.

It is well known that ochres alſo form the baſis of various kinds of pigments, paints, and other ſimilar matters.

Oil

OIL, in *Chemiſtry* and the *Arts*. Oils are divided into two claſſes: A. *Volatile*, and B. *Fixed oils*. The latter into two orders; *a*, fat, and *b*, drying oils.

A. *Volatile or Eſſential Oils.*—Theſe are ſo called becauſe they are evaporable at a moderate heat without decompoſition, and becauſe in them the odour or fragrance, or as the old chemiſts called it, the *eſſence* of vegetables conſiſts. Oils of this kind are obtained generally from vegetables, and ſome varieties from animals. They are extracted from the roots,

leaves, flowers, ſeeds, and fruits of vegetables, but ſeldom from ſeeds with two cotyledons, which generally afford the fixed oils; while the huſk, or cover of the ſeed, is always more or leſs impregnated with volatile oil, the acrimony of which defends in ſome degree the rudiments of the young plant from the depredations of inſects. The volatile oils, which are procured from the fruits of the lemon, the orange, and the bergamotte orange, are thoſe which alone are capable of being obtained by expreſſion. For this purpoſe a ſmall wheel, with its circumference ſet with ſtout nails, is put in motion, and a lemon or orange is applied to it till the whole of the yellow outer rind is raſped away. The raſpings fall to the bottom of the caſe in which the wheel turns, and they are then ſqueezed between two plates of glaſs. By this gentle preſſure the eſſential oil flows from the ruptured cells into any adjoining veſſel, and is there ſuffered to reſt till the water and other impurities have ſubſided. In a way ſimilar to this is obtained in India the precious perfume called the oil or "otter" of roſes. For this purpoſe a clean caſk or glazed earthen jar is filled with roſe-leaves ſeparated from its calyces, which are covered with ſpring-water. The veſſel is then ſet in the ſun for two or three days, and brought under cover in the night. At the end of the third or fourth day ſmall particles of yellow oil will float on the ſurface of the water, which in a week will have accumulated into a thin ſcum: this ſcum is taken up by a little cotton tied to the end of a ſtick, and ſqueezed into a ſmall phial.

Eſſential oils are generally obtained by diſtillation. The freſh herbaceous plant, or the dried plant, previouſly macerated for a few hours in water, or the bark or wood raſped or cut into ſhavings, and macerated for ſeveral days, are cloſely rammed down in a tinned copper ſtill or alembic; and when covered with water, the head of the ſtill is luted on and the refrigeratory filled with cold water, and then the fire is lighted and ſo regulated as to keep the contents of the ſtill conſtantly ſimmering, without boiling. The ſteam condenſed in the worm will form a ſmall ſtream of water, which is to be collected in proper veſſels, till it comes off nearly inſipid and inodorous; and then the diſtillation is ſtopped. The firſt part of the produce, as it is turbid from ſuperſaturation with eſſential oil, is kept for ſome hours in a cold place, during which time the exceſs of oil will ſeparate from the water, and either float on the ſurface or ſink to the bottom, according to its ſpecific gravity. The oil is completely ſeparated from the diſtilled water by an inſtrument called the Italian recipient; and the whole of the water produced by the firſt diſtillation is employed in the next, inſtead of plain water; ſo that thus the produce of oil in the ſecond diſtillation will exceed that of the firſt, by the whole quantity held in permanent ſolution by the water of the former proceſs. By this proceſs, the amount of oil yielded by equal quantities of the ſame ſubſtance will form a conſtantly increaſing ſeries, till the whole of the water drawn off by each diſtillation is completely ſaturated with oil. It is not till the ſeventh, or even ſometimes the tenth diſtillation, that the produce of oil attains its maximum. Eſſential oil may be procured not only from odorous vegetables themſelves, but from ſuch of the immediate products of vegetation as poſſeſs any odour: ſuch are the balſams and many of the reſins and gum reſins. The peculiar odour of vegetables, when not in a ſtate of decompoſition, depending on the volatile oil they contain, it is plain that the odours of the oil themſelves are equally various. Their taſte is exceedingly hot and pungent, and in ſome, particularly the oil of peppermint, followed by a remarkable ſenſation of coldneſs, though the thermometrical temperature undergoes no change. The acrimony of ſome of the oils, as the oil of cloves, is ſo great as actually to deſtroy the outer ſkin of the tongue and of other ſenſible parts. The colours of eſſential oils are various, ſome being blue, others green; but the uſual colour is light yellow, verging more or leſs by long keeping to reddiſh-brown. Other ſtriking characters of volatile oils are that they are liquid, more or leſs at different temperatures, ſometimes thick and glutinous like the expreſſed oils, and ſometimes ſolid and in cryſtals. In the latter ſtate they approach the nature of reſins. They are highly combuſtible, producing much ſmoke, condenſing into ſoot. They are alſo of an agreeable ſtrong ſmell, and of a pungent acrid taſte. They are volatile at a heat leſs than 212°. And they give a greaſy ſtain to paper, but evaporate without leaving any mark. Volatile oil, however, may be detained in a higher heat by mechanical mixture with dry clay or ſand; and then it undergoes a partial decompoſition, carburetted hydrogen being given out, and a little charcoal remaining in the receiver; the undecompoſed reſidue, if ſubjected three or four times ſucceſſively to ſimilar treatment, will be entirely deſtroyed.

The following table exhibits the moſt prominent properties of ſome of the volatile oils.

TABLE of Volatile Oils.

Names.	Colour.	Specific Gravity.	Conſiſtency at 60°. Freezes at 14°.	Odour.
Turpentine - -	None.	.792	Fluid as water.	Strong.
Juniper - -	Green.	.611	Very fluid.	Strong ſmell.
Roſemary - -	None.	.934	Thin liquid.	Like the plant.
Mint - -	None.	.975	Very fluid.	Agreeable.
Cloves - -	None.	1.034	Oily and very fluid.	Very fragrant.
Lemon - -	Yellow.		Thin liquid.	Very agreeable.
Orange - -	Yellow.	.888	Ditto.	Nearly ſimilar.
Cinnamon - -	Yellow.	1.035	Oily and leſs liquid.	Pleaſant.
Saſſafras - -	None.	1.094	Oily.	Like the root.
Fennel - -		.997	Becomes ſolid at 50°.	
Tanſy - -		.946		Very ſtrong.
Dill - - -		.994		
Carraway - -	None.	.94		Very ſtrong and pungent.
Penny Royal - -		.978		Agreeable, like the plant.
Cummin - -		.975		

Names.	Colour.	Specific Gravity.	Confiftency at 60°. Freezes at 14°.	Odour.
Nutmegs - -	None.	·948	Like butter.	Very pleafant.
Anifeed - -	None.		Becomes folid at 50°.	Very ftrong.
Thyme - -	Brown.		Cryftallizes.	Like camphor.
Spike - -	Yellow.	·936		Very ftrong.
Lavender - -	None.		Thin liquid.	Very agreeable.
Origanum - -		·94		Very ftrong and acrid.
Wormwood - -	Green.			
Camomile - -	Blue.			
Hops - - -	Green.		Like butter.	Like the flower.
Parfley - -	Green.			
Bergamotte - -	Yellow.		Not oily. Is folid at 23°.	Very pleafant.
Cardamom - -	None.		Oily.	
Mace - -			Oily.	Agreeable.
Rofes - -	None.			
Peppermint - -	Green.		Thin liquid.	Very agreeable.
Savine - -	None.			Difagreeable.
Pepper - -	None.		Like butter.	Very acrid.

When the volatile oils are recently diftilled they evaporate without leaving any refiduum. They are diftilled with greater facility when water or alcohol is prefent. After they have been expofed to the air for fome time they do not entirely evaporate, but a flight refiduum is left of the nature of refin. When deprived of heat to a certain extent they become folid, having an unctuous appearance. Some of them affume the cryftalline form.

It has been afferted by Tingry, that light has the property of increafing the abfolute weight of the volatile oils when expofed in a clofe glafs veffel, the air at the fame time being excluded. This fact, however, ought to be doubted, till confirmed by ftronger evidence. This he attributes to the fixation of light, a thing at prefent unknown to chemifts. The effential oils, efpecially the more volatile of them, deoxygenate atmofpheric air very completely, as was firft afcertained by Dr. Prieftley, and this circumftance partly accounts for the uneafy fenfations experienced by moft perfons when in a clofe newly painted room.

The action of oxygen upon thefe bodies is very confpicuous. They become vifcid, and affume a yellow colour. The colour becomes deeper, more efpecially if it is expofed to the fun, and the oil ultimately affumes the form of refin. In thick oils another change takes place; a weakly acidulous water is produced, and prifmatic cryftals are depofited; the refidue of the oil becoming, in the mean time, concrete. Thefe cryftals, which have been occafionally miftaken for camphor, are flightly foluble in hot water, and more fo in alcohol; to which they communicate the property of reddening vegetable blues; when gently heated, they fwell and cryftallize in needles by cooling; when heated by the blowpipe they evaporate, but do not inflame; from thefe properties they have been confidered as an acid very analogous to the benzoic. Some effential oils afford real camphor by evaporation, as Proult has fhewn. (See CAMPHOR.) If the mafs fo changed into refin be fubjected to diftillation, an oil fimilar to the original comes over, leaving behind a refin of greater hardnefs, and more infufible than the original mafs. Almoft all the fubftances denominated refin are capable of affording a portion of an effential oil by the action of heat, the refin becoming harder and lefs fufible. It is on thefe facts that the art of japanning depends. If the furface of any body be covered with common tar, and then expofed to the heat of a ftove for a certain time, the oily part evaporates, leaving a hard coating, which does not foften at a heat fhort of that which would decompofe it, and at the fame time fo hard as not to be penetrable by the nail. Common pitch and refin are of different degrees of foftnefs, according to the extent to which the diftillation has been carried. The change produced in the volatile oils, by expofure to the air, has been fuppofed to arife from the abforption of oxygen, but in all probability this is not the fact. That oxygen difappears is undeniable, but that it is retained in the body is doubtful. We are informed by Fourcroy, that drops of water are formed when oxygen is expofed over oil of turpentine. Hence it is highly probable, that the oxygen combines with the hydrogen of the oil, forming water, which leaves a compound having lefs hydrogen, and in confequence more fixed and hard.

The volatile oils, from the great quantity of hydrogen they contain, take fire with great facility, and burn with a copious white flame, producing much foot. If the products of combuftion be collected, they will be found to confift of water and carbonic acid, derived from the carbon and hydrogen of the oil, with the oxygen of the atmofphere.

It is by this means that we are to expect an analyfis of thefe fubftances, an object which has not yet been accomplifhed, but which is very defirable.

The volatile oils do not undergo any change with hydrogen or carbon. They combine to a certain extent with fulphur, by which they acquire a brownifh colour, and difagreeable fmell. This fulphurized oil gives out on diftillation fulphuretted hydrogen; it is often called "balfam of fulphur."

It is faid that thefe compounds are decompofed by heat with a violent effervefcence, which is fuppofed to arife from the fulphur combining with the hydrogen, forming fulphuretted hydrogen.

Camphor, which may be deemed a concrete volatile oil, combines with phofphorus by trituration. This compound may afterwards be diffolved in moft of the volatile oils. The folution is luminous when expofed to the air, fo as to tell the hour of the night.

Water has little action upon the volatile oils. The water, however, diffolves as much as gives it a ftrong tafte of the oil. When the oil is firft dropped upon fugar, and this put into water, a greater quantity is retained. Advantage is frequently taken of this fact in pharmacy.

They are moftly foluble in alcohol and ether, though in limited proportions.

The alkalies have much lefs action upon the volatile oils than upon the fixed oils. They are more fusceptible of combining with thefe bodies, in proportion as they approach the ftate of refin. Common turpentine combines with potafh, while oil of turpentine is but with difficulty made to unite with it. This has been called *Starkey's foap.*

We are in poffeffion of fome facts relative to the action of acids upon the oils.

The fulphuric acid diffolves them, and mutual decompofition takes place. The colour becomes dark, and charcoal is at length depofited. When water is poured upon the folution, a refinous mafs becomes feparated. Hence it appears, that the oxygen of the fulphuric acid produces a fimilar change with the oxygen of the atmofphere.

The nitric acid, when poured upon moft of the effential oils, caufes them to inflame with great violence, leaving behind a fpongy coal of a brown colour. The acid fhould be very ftrong for this experiment.

Muriatic acid flightly diffolves thefe fubftances, but we have no facts as to their mutual change.

It may eafily be conceived, that many of the metallic oxyds will produce the fame changes upon the volatile oils which are produced by the acids, and the oxygen of the atmofphere. The facility with which lead, mercury, and manganefe give up their oxygen, offers a ready method for an accurate analyfis of thefe bodies.

The volatile oils are ufed in medicine, and are confidered ftimulants. They are alfo ufed as perfumes; and in the compofition of varnifhes and oil paints.

Fixed, Vegetable, or Unctuous Oils.—The fixed oils have the following characters:

1. They are greafy to the touch.

2. They are moftly liquid, or rather in the ftate of a moderately thick, but not vifcid, fluid, at the common temperature of the atmofphere, but become folid at certain degrees below.

3. They do not boil at lefs than 600°.

4. They take fire at a certain temperature, and burn with different degrees of brilliancy.

5. They are not acrid like the volatile oils, but frequently almoft infipid, or poffeffing a mild fub-naufeous tafte, and a peculiar flavour, according to the vegetables from which they are produced. Their colour, when recent, has more or lefs of a greenifh tinge, which by keeping becomes yellow, and in fome inftances orange-coloured, verging on red. Their fpecific gravity is ufually between that of alcohol and water, as they fink in the former, and float on the furface of the latter. Of thefe fluids, there is no circumftance in which they differ fo much as in the temperature at which they congeal: fome continue folid at the higheft atmofpherical temperature, as palm oil, and the reft of the vegetable "butters," as they are called from this circumftance; others require being cooled down to the freezing point of water; and others, again, are capable of enduring a much greater degree of cold without becoming folid.

6. They are infoluble in water and alcohol.

7. They leave a ftain on paper, which cannot be removed by evaporation.

Fixed oils are fo called, becaufe they are incapable of being volatilized by heat without decompofition. When any of them, *e. g.* olive oil, is heated in a clofe diftillatory apparatus, as foon as the fluid has arrived at its boiling point, a white vapour is difengaged, confifting of oil, carburetted hydrogen, and carbonic acid. The firft of thefe is for the moft part condenfed in the receiver; while the other two, retaining in folution a portion of oil, efcape in the form of permanent gas: and when every thing volatile has been driven off, nothing remains in the retort but a little charcoal. The oil which is found in the receiver is lighter, more limpid and volatile, than that from which it was procured; and thefe qualities are obferved to increafe by each fucceffive diftillation; carbon and carburetted hydrogen being difengaged as at firft. By continuing this procefs with the product of each diftillation, the oil at length entirely difappears, being partly decompofed, and partly carried off in folution by the carburetted hydrogen gas.

They are principally procured from the cotyledons of feeds, and fometimes, though rarely, from the pulp or flefh of fruits. The fubftance containing the oil is beaten to a pulp, and then heated to a certain temperature. It is then fubjected to the action of a ftrong prefs, to force out the oil. Much of the mucilage is carried off with the oil. This is more particularly the cafe when the pulp is heated. If it be preffed cold, the oil is much freer from colour, and in a ftate of greater purity; but the quantity obtained is lefs. The oil obtained in this way is faid to be *cool drawn.* If the heat be too great, the oil will be more coloured. The kernels of the common nut, the walnut, and the hickory nut, yield an abundance of oil: it is alfo expreffed from the feeds of the lint, the rape, the poppy, and the fun-flower; and in great abundance from the exterior fubftance of the olive. All the fixed oils, except the latter, are obtained from the cotyledons of feeds; and it is remarkable that no feed with one cotyledon affords a fixed oil. Oil may be extracted not only by preffure, which is the moft common method, but by immerfion in hot water. In this latter cafe, the oil feparates from the other ingredients with which it is naturally mixed, and rifes by the force of gravity to the furface of the water, from which it is fkimmed off. Recently drawn oil is more or lefs impure, on account of its containing a variable proportion of mucilage, fecula, and perhaps other fubftances: of thefe a part is always depofited by reft, efpecially if the contact of the air is not wholly excluded; but another portion remains in permanent folution; and to this that partial fpontaneous decompofition in oils, called "rancidity," is principally owing. They are alfo obtained from animals, fuch as whale oil and neat's-foot oils.

All animals, except thofe included in the clafs of infects, contain oil; the quantity of which, as well as its fituation in the body, is fubject to confiderable variety. (See CELLULAR *Membrane*, ADEPS, and SEBACIC *Acid*. See alfo *Anatomy of* BIRDS, FISH, and MAMMALIA.) While the fat remains in the living body, it is always in a fluid or femi-fluid ftate; but its confiftence changes, when it is extracted and expofed to the common temperature. The oil or fat, invefting the kidnies of quadrupeds, is called fuet or tallow, and is the hardeft and moft folid of any; the next in hardnefs is the fat of the bones, and that in which the mufcles are imbedded is the next in degree: the fat of the hog, called "lard," is the leaft folid. The fat of birds is feldom fo folid as hog's lard, and in many fpecies is actually fluid. The fat or oil of fifh is almoft always fluid at the common temperature. There is alfo fat in the yolk of eggs, which may be extracted by fimple preffure, after the yolk has been coagulated by heat.

Animal oil is obtained in its pureft ftate by fhredding frefh fuet, and liquefying it in boiling water, and then paffing it through a piece of thin gauze, in order to feparate the cellular membrane. Thus purified, its colour is yellowifh-white: it is moderately hard, of a mild tafte, and almoft deftitute of odour or flavour; it is combuftible, like the fixed vegetable oils, and agrees with thefe in the changes produced upon it by the alkalies and other chemical re-agents.

All the animal oils belong to the clafs of unctuous or fat oils, none of them being either drying in themfelves, or capable of becoming fo by means of litharge and other fubftances. Fat, expofed to dry diftillation, when it acquires the temperature of about 400°, emits a white acrid and difagreeable vapour: as the heat increafes, fome of the oil comes over into the receiver, and that which remains in the retort acquires a blackifh tinge; empyreumatic, acetous, and febacic acids manifeft themfelves, together with carburetted hydrogen and carbonic acid of a very offenfive odour. Hence it is inferred that there is a real difference between animal and vegetable oils, though it has not been pointed out by chemical analyfis. The coarfer kinds of animal oil, extracted by putrefaction and a ftrong heat, poffefs a much more difagreeable odour than any of the vegetable oils; and, when rancid, difengage ammonia by the action of the fixed cauftic alkalies, in which they alfo differ from the latter. The fifh oils, always rancid, are for the moft part thick and glutinous, which renders them in fome degree unfit for burning, and fome other ufes to which they are applied. Many attempts have been made to meliorate them; and it appears by the experiments of Mr. Doffie, that they may be confiderably improved by means of fixed alkali and chalk, by which the albumen and gluten are thrown down, and the fupernatant oil, after due reft, may be poured off in a fluid ftate, and very fenfibly amended in confiftence, odour, and fitnefs for burning. Animal oils are fubftances of very great economical importance. They are ufed as food, and in medicine as the bafis of various unguents: they are largely employed in the manufacture of foap, and alfo for burning either in lamps or in the form of candles. Aikin's Dict.

Whale oil is much contaminated by different animal matters, to which it owes its difagreeable odour. It has, however, been fo purified as to poffefs lefs fmell and tafte than the beft olive oil.

All the fixed oils are of lefs fpecific gravity than water; and fince they do not combine, the former muft float upon the furface of the latter.

The fixed oils cannot be diftilled without decompofition. They boil at 600°: a vapour comes over, which condenfes into an oil, which is different from the original. An inflammable gas is difengaged, and fome coal depofited. This is fome proof that decompofition takes place. From thefe facts we may fairly conclude, that the oil of lamps and candles, when in the act of burning, undergoes decompofition. The inflammable gas and the vapour conftitute the volatile part which makes the flame, while fome carbon is feparated, which lodges in the wick.

Fixed oils are divided into two orders: (*a*), *fat oils*, and, (*b*), *drying oils*.

(*a*). *Fat Oils*.—Thefe are fuch as, when expofed to the air for a certain time, firft become vifcid, and ultimately concrete, having the appearance of tallow, and in every refpect fimilar to fat. This oil will be more or lefs hard, according to the time expofed: it at the fame time acquires a difagreeable odour, to which we give the name of rancidity. Of thefe kinds we may mention olive oil, almond oil, and that extracted from rape feed, called rape oil. This change is more rapidly brought about by dilute nitric acid, or any fubftance which affords oxygen. It has been fuppofed that the combination of the oxygen with the oil gives to it the concrete form. It is, however, to be regretted that we have not as yet learned from any experiments, whether the abfolute weight of the oil be increafed or diminifhed by the agency of the oxygen. It feems moft plaufible to fuppofe, that the oxygen combines with a portion of hydrogen of the oil, forming water, leaving the remainder more concrete and lefs fufible. Olive oil, by treating it with nitric acid, may be rendered equally infufible with fpermaceti.

The fat oils combine with the alkalies, earths, and moft metallic oxyds, forming foaps. See SOAP.

They are not mifcible with water, except through the medium of fugar, ftarch, or gum. With the two latter they form compounds, called *emulfions*.

They do not combine with many of the combuftible bodies. They unite with fulphur, forming a dark brown compound of a difagreeable fmell. On cooling, fome of the fulphur is depofited in cryftals. Phofphorus combines with feveral of the fat oils. Olive oil, when rubbed with phofphorus in a mortar, diffolves a portion of it. The folution, when expofed to the air, by opening the bottle containing it, becomes very luminous. Any fubftance fmeared with it fhines for fome time, but no perceptible heat is produced.

When concentrated fulphuric acid is poured upon the fixed oils, decompofition fpeedily enfues. The products are water, carbon depofited, giving a black colour. The fulphur is alfo depofited, and fome acetic acid formed. When concentrated nitric acid is poured upon oils, the action is confiderable; the oil takes fire, and burns, leaving a fpongy coal behind. If the acid be dilute, as has been obferved, it converts the fat oils into fat like tallow.

The fixed oils combine with fome of the metals. A leaden veffel foon becomes corroded by oil contained in it; the oil at the fame time becoming thicker. They have fcarcely any action upon tin; hence the ufe of the latter metal in preference to the former for oil veffels. Oil has alfo a decided action upon iron, as we fee in the axle-trees of carriages, and in all inftances in which oil is ufed with iron to leffen friction.

b. *Drying Oils*.—Thefe oils poffefs properties moftly common to both, but differing in fome particulars. They, like the fat oils, become concrete by the action of oxygen; but inftead of affuming an opaque fatty appearance, they retain their tranfparency, and acquire the flexible property of horn.

The varieties poffeffing this property are the oils of nut, poppy, and lint.

Thefe oils are lefs fitted for combuftion than the fat oils, but are of great ufe for paints and varnifhes, and making printers' ink. When ufed for the latter purpofe the nut oil is preferred, on account of its not turning yellow. It is firft fet on fire, and allowed to burn for a fhort time; it is then covered by a lid to extinguifh it, and allowed to boil for fome time. By this treatment it lofes its greafy quality, becomes thick and roapy, and is more mifcible with water, a property of great importance in the above application. Drying oils become more fufceptible of the concreting quality by being boiled with litharge, or almoft any fubftance containing oxygen. Doubtlefs in this procefs the oxygen of the lead combines with the hydrogen of the oil, while the lead combines with the oil, to which it gives a dark colour, and makes it thicker. Acetat of lead, and other metallic falts, produce the fame change.

When oil is mixed with the black oxyd of manganefe, it fome time after takes fire. This arifes from a more rapid combination of the oxygen of the oxyd with the hydrogen of the oil.

The compofition of the fixed oils has been given by Lavoifier, but it is not to be relied upon. He makes it confift of 79 carbon, and 21 hydrogen.

Another fpecies of oils is found in fome vegetables, which have an acrid tafte, and diffolve in alcohol, like the

volatile oils, but are not so volatile as to admit of distillation. The vegetable containing the oil is infused in alcohol, which dissolves the oil. The alcohol is afterwards distilled from the oil.

These oils are said to be poisonous, which appears to be their most distinguishing character. An oil of this kind is obtained from the root of the helleborus hyemalis, and another is found in tobacco.

Oils, *Empyreumatic*.—These approach the nature of volatile oils, and are formed during the distillation of vegetable and animal substances. They have properties nearly allied to tar, and afford, by a second and careful distillation, a liquid volatile oil, not much unlike the oil of common tar, which has many properties in common with oil of turpentine. A similar substance is obtained from pit-coal by distillation, which oil belongs also to this class.

The colour of empyreumatic vegetable oil is yellowish-red, passing into blackish-red; it has a strong odour, and an acrid empyreumatic taste; it is more volatile than the fixed oils, but less so than the proper essential ones; by re-distillation with a little water it almost wholly loses its colour, and becomes more volatile than before, though still possessed of much of its empyreumatic flavour. See Aikin's Dict.

The use of oil in stopping the violent ebullition of various substances, may be very great in many occasions of life. It is well known that if a mixture of sugar, honey, or the like, be boiling on the fire, and in danger of rising over the sides of the vessel, the pouring in a little oil immediately makes it subside. In many cases, the marking a circle round the inside of a vessel, in which a liquor of this kind is to be boiled, with a piece of hard soap, shall, like a magic ring, confine the ebullition to that height, and not suffer it to stir any farther. This is wholly owing to the oil, or fat, contained in the soap; but there is, besides these, another very important use of oil, on a like occasion, which is the pouring a little of it on any metallic solution, while making; this restrains the ascent of the noxious vapours; preserves the operator from danger; and, at the same time, by keeping down the evaporating matter, gives redoubled strength to the menstruum.

Pliny has mentioned an extraordinary effect of oil, in stilling the surface of water when it is agitated with waves, and the use made of it by the divers, for this purpose. "Omne," says he, "oleo tranquillari," &c. lib. ii. cap. 103. and Plutarch, in Quæst. Natur. asks, "Cur mare oleo conspersum perlucidum sit et tranquillum?" Pliny's account seems to have been either discredited or disregarded by our writers on experimental philosophy, till it was confirmed by several curious experiments of Dr. Franklin, which were published in the year 1744.

The property of oil above-mentioned has, however, been well known to modern divers and dredgers for oysters, at Gibraltar, and elsewhere. The divers in the Mediterranean, in particular, descend, as in Pliny's time, with a little oil in their mouths, which they now and then let out; and which, on rising to the surface of the sea, immediately renders it smooth, so as to permit the light to pass through the water, undisturbed by various and irregular refractions.

The Bermudians, it is said, are enabled to see and strike fish, which would be concealed from their view, through the roughness of the sea, by pouring a little oil upon it. And the Lisbon fishermen effect a safe passage over the bar of the Tagus, by emptying a bottle or two of oil into the sea, when the surf is so great as to endanger its filling their boats. Our sailors have also observed, that the water is always much smoother in the wake of a ship that hath been newly tallowed than it is in one that is foul.

Dr. Franklin was led, by an accidental observation made at sea in 1757, to attend particularly to Pliny's account; and the various informations which he afterwards received relating to it, induced him to try some experiments on the subject. Standing on the windward side of a large pond, the surface of which was rendered very rough with the wind, he poured a tea-spoonful of oil on the water. This small quantity produced an instant calm over a space of several yards square. which spread amazingly, and extended itself gradually, till it reached the lee-side, making all that quarter of the pond, perhaps half an acre, as smooth as a looking-glass. On repeating this experiment, which constantly succeeded, one circumstance struck him with particular surprize; this was the sudden, wide, and forcible spreading of a drop of oil on the face of the water, which, he adds, "I do not know that any body has considered."

When a drop of oil is put on a looking-glass, or polished marble, it spreads very little: but on water it instantly expands into a circle extending several feet in diameter, becoming so thin as to produce the prismatic colours for a considerable space, and beyond them so much thinner as to be invisible, except in its effects of smoothing the waves at a much greater distance. It seems, says Dr. Franklin, as if a mutual repulsion between its particles took place as soon as it touched the water, and a repulsion so strong as to act on other bodies swimming on the surface, as straws, leaves, &c. forcing them to recede every way from the drop, as from a centre, leaving a large clear space. The quantity of this force, and the distance to which it will operate, the author says, he has not yet ascertained; but he thinks it a curious enquiry, and wishes to understand whence it arises. In endeavouring to account for the singular effects of oil, Dr. Franklin observes, that there seems to be no natural repulsion between water and air, so as to keep them from coming into contact with each other. Therefore air, in motion, which is wind, in passing over the smooth surface of water, may rub, as it were, on that surface, and raise it into wrinkles, which, if the wind continues, are the elements of future waves. The smallest wave does not immediately subside, but in subsiding raises nearly as much of the water next to it. A small power, continually operating, will produce a great action: so that the first raised waves, being continually acted upon by the wind, are, though the wind does not increase in strength, continually increased in magnitude, rising higher and extending their bases, so as to include a vast mass of water in each wave, which, in its motion, acts with great violence. But if there be a mutual repulsion between the particles of oil, and no attraction between oil and water, oil dropt on water will not be held together by adhesion to the spot on which it falls; it will not be imbibed by the water; but be at liberty to expand itself and spread on a surface, that prevents, perhaps, by repelling the oil, all immediate contact; the expansion will continue till the mutual repulsion between the particles of oil is weakened, and reduced to nothing by their distance.

Dr. Franklin imagines, that the wind blowing over water, thus covered with a film of oil, cannot easily catch upon it, so as to raise the first wrinkles, but slides over it, and leaves it as smooth as it finds it. It moves a little the oil, indeed, which being between it and the water, serves it to slide with, and prevents friction: hence the oil dropt on the windward side of the pond proceeds gradually to leeward, as may be seen by the smoothness it carries with it quite to the opposite side: for the wind, being thus prevented from raising the first wrinkles, which he calls the elements of waves, cannot

produce waves, which are to be made by continually acting upon and enlarging those elements, and thus the whole pond is calmed.

Upon the whole, there is great room to suppose (notwithstanding the partial failure of an experiment made at Portsmouth, by Dr. Franklin, and others), that sea-faring people may derive advantages from using oil on particular occasions, in order to moderate the violence of the waves, or to lessen the surf, which sometimes renders the landing on a lee-shore dangerous, or impracticable.

To this purpose we are informed that the captain of a Dutch East India ship, being overtaken by a storm, found himself obliged, for greater safety in wearing the ship, to pour oil into the sea, to prevent the waves breaking over her, which had an excellent effect, and succeeded in preserving her. Phil. Transf. vol. lxiv. part. 2. p. 445, &c.

Oil, in *Agriculture*, a fatty unctuous material, obtained from animal as well as vegetable substances. These matters are distinguished into different kinds, as ethereal or essential, and fat or fixed oils: the former are acrid, volatile, odoriferous, and exist in the plants in the same states in which they are found; while the latter are fixed, destitute of odour, and mild to the taste. These last, when kept a long time, corrupt and become rancid. They do not act upon earths, but readily combine with alkaline salts, with which when caustic they form vegetable soaps.

Though these matters cannot be employed by the farmers in their simple states, as being too expensive, and having rather a noxious or poisonous effect, than a beneficial one on the growth of plants, they may frequently be used in the condition of composts with advantage, as has been the case in the application of various of the grosser sorts of materials of this nature, such as those of whale blubber, the bottoms and refuse of oil casks, &c. when blended with earthy materials, so as to be laid upon the land in an even and regular manner. And in this state of combination they have been found, by the experiments of different cultivators, to form very strong and powerful manures.

The account of Mr. C. Baldwin's trials made with the bottoms or *foots* of oil, and a rich thick South-sea whale oil, in the whole sixty gallons, is thus stated.

Having a platform or bottom of twenty loads of mould, with eight loads of dung on it, he carried on three loads of light sandy mould, and one load of brick and mortar rubbish, ground fine, and having mixed these well, and made a kind of dish of it, about five feet wide and ten feet long, with a ladle he had put over it one-half of the oil. It was in August, and the warmth of the sun soon made the thick oil soak into the compost, when it was directly thrown up in a heap, broke down again, and by five or six turnings well mixed together, and left in a heap two days, when it was spread equally over the whole dunghill; twenty loads more of good mould were then carried on, eight loads of dung, and the remaining thirty gallons of oil were mixed as before, in sandy mould, and brick and mortar rubbish, and equally spread over, and the whole was covered by trimming the four sides of the dunghill, and throwing it on the top. And thus the dunghill lay more than two months, when it was cut down by mattocks, carefully broke, well mixed, and turned over. The end of March it was carried on the field, spread and ploughed in; it lay about a fortnight, and was then ploughed again, and on the 22d of April it was drilled with the Rev. Mr. Cooke's excellent drill. The field was drilled with barley, two bushels to the acre; the crop came up in a most even and beautiful manner; every seed was up within forty-eight hours of each other; all was ripe at the same time, and, from a couple of months after seed-time to harvest, was rated by all who saw it, and it was seen by many, as a sixty bushel crop. At harvest, three rows were cut across the field, directly thrashed and measured; one load out of thirteen was also thrashed and measured, and both stated the crop to be sixty bushels; but to wave all possibility of dispute or doubt, he is content to state the crop at seven quarters *per* acre. As to the quality of the barley, he could here cite the opinion of one of the most eminent brewers in London, who saw the crop growing, and declared he would readily give 1000*l.* to be assured that all the barley crops in the kingdom were of equal burthen and weight; five quarters of it have been lately sent to Nethrapps, in Norfolk, as seed-barley, under the denomination of 15 comb-barley; and an eminent maltster tells him it weighs 220lbs. *per* sack, or 55lbs. *per* bushel, Winchester measure. It is added, that among the many gentlemen and farmers who saw the crop on the ground, was the celebrated Mr. Bakewell; he came with three or four others, and walking down the field, observed the hedge and bank; the bank, upon being touched with a stick, run down as sand and gravel generally do, and Mr. Bakewell being asked his opinion of the value of the land, if he does not mistake, valued it at 18*d.* *per* acre, but turning to the crop, and desiring his friends to do so also, he admitted that it seemed as if growing on land of 15*s.* or 20*s.* *per* acre. He must not omit saying that the barley followed oats, upon a lay of six years old; that the land was, as is too common in such cases, much infested with the little red or wire worm, and that the oats suffered much from them; when they were ploughing for the barley the first time, he observed many turned up by the plough, when a distant ray of hope instantly darted upon his mind, that the soil in its then state, or from its strong effluvium, might prove obnoxious to them, and he is happy in saying, that the barley did not suffer from them in the least.

It is further stated, that he is trying the experiment in Hampshire, having last autumn made up a dunghill, with twenty gallons of oil, on one-third of it for a six-acre field, which is now drilled with pease.

And he concludes by observing, that it is well known that all animal substances, in a state of corruption, wonderfully promote vegetation, and are the actual food of plants. The whale-oil which he used is an animal substance, perhaps the richest part of the animal; whether he used enough, or what is the proper quantity *per* acre, experience must point out; say he used eight loads of mould, three or four loads of dung, and twelve gallons of whale-oil *per* acre. That oil applied to land, as a food for plants, in its crude state, acts as a poison he cannot deny; but his process is very different: he believes that oil, particularly animal-oil, is the pabulum of plants, that is, oil subtilized by the salts in a compost dunghill, left there a considerable time in a state of putrefaction, and until the whole is become putrescent; then he believes he has got the best and richest manure that can be carried on land. The barley evidently proved its excellence; a ridge of summer cucumbers in his garden pointed out to many its great power, the leaves being in general from ten, to ten and a half inches broad, and the vines occupied an uncommon space of ground. Five hundred cabbages and savoys, planted by the side of four thousand more, and which had only one handful of the oil manure put in each hole made by the dibble at the time of planting, were evidently near as big again as the others. See Oil-*Compost*.

Oil-*Cake*, the cake which remains after the oil has been expressed from flax, rape, and some other sorts of seeds. Cakes of the first sort are found to be extremely beneficial in the fattening of cattle, sheep, and other animals, in different

districts, where they are made use of upon an extensive scale.

A recent writer has stated, that the late advances in the price of this article, have probably rendered it incapable of being made use of with much profit, except in particular cases, and where manure is a principal object: with this sort of food it is the common practice to give some other sort of meat, such as hay, cut chaff, and other substances of the same nature, and some begin by giving to a beast of a hundred stones, two cakes *per* day of about six pounds each, for six or eight weeks, and then increase them to three, till the animals become fat: at first, however, as the animals seldom like it, much less may be found sufficient. In addition to the cake, from half a stone to a stone of hay is given each day, the whole consumption in cake being about 21 cwt., and in hay 26 cwt., which at the prices previous to the late advance on these articles, rendered the expence of winter-fattening an animal of the above size something more than seven guineas: lean cattle of the smaller kinds have been made perfectly fat in the course of eight or ten weeks by this substance in the trials of Mr. Moody. The cake in this application is broken down into small parts, and frequently blended with the chaff or other substances that are made use of with it. On the continent, Mr. Young says, linseed cake is sometimes exhibited in a liquid state, being diffused in hot water, and drank by the cattle, hay and other substances being given at the same time. And in the Lincolnshire report, a method is suggested of giving cake to cattle while in the pastures in a small proportion, with great success, a practice which may be applicable, where the cake-fed beasts are not fully fattened for sale in the early spring months. It is an advantage in fattening with this and other similar substances, that the animals may be completed with them at much more advanced ages than in other modes of fattening.

But wherever this expensive sort of food is employed, great care should be taken that the cakes be fresh, good, and free from mouldiness. They are the best where the expression of the oil has not been carried too far, but where this has happened they are mostly deficient in nourishment.

It has been stated by Mr. Donaldson, that in Lancashire, Yorkshire, Norfolk, and a few other districts, they sometimes use oil-cakes of the latter kind, after being reduced to powder by means of a machine contrived for the purpose, as a manure, sometimes for wheat and barley crops, but more generally for turnips. It is always sown by hand, and harrowed in with the seed. The quantity used is from three to six quarters the acre. The price is extremely different in different districts. It was then in Lancashire from six to eight shillings the quarter, in some parts of Yorkshire from sixteen to twenty. Experience has proved, that the success of this manure depends in a great measure on the following season. If rain happens to fall soon after the rape-dust is applied, the crop is generally abundant, but if no rain fall for a considerable period, the effects of this manure are little discernible either on the immediate crop, or on those which succeed it on the land in the following year.

And in an experiment stated in the eleventh volume of the Agricultural Magazine, four ridges, about twenty yards wide each, in the middle of a large field, were alternately manured with lime and rape-seed cake. The quantity of lime was, it is supposed, three chaldrons to an acre. The part oil-caked had a quarter of a ton an acre drilled by a machine, which throws the oil-cake reduced to powder, and the turnip seed, into the same drills. The soil was a strong dry red loam, with a few spots of gravel interspersed in different parts of the field. On these gravelly spots the turnips were rather superior on the parts which were limed; but on the loam the oil-caked ridges produced, at least, double the weight of those which were limed.

Mr. Calvert, at Albury, when oil-cake was much cheaper than at present, found it the most advantageous and profitable food that he could give his cows; three cakes a day, with eight or ten pounds of hay, or four cakes and good straw, were the usual allowance; two were given to cows in calf and growing heifers: he practised this till cake advanced beyond 9*l.* a thousand. How far it may answer at much higher prices, hay and butter having both greatly advanced, careful experiments will alone ascertain, which he himself should have made, but, Swedish turnips being introduced and answering uncommonly well, he lost the inducement to go on with the other food. Cake gave very good butter, and at 6*l.* or 7*l.* a thousand was the cheapest food that could be given. Hertfordshire Agricultural Report.

Good potatoe crops have been raised by it in some parts of Lancashire.

Oil-*Compost*, a substance of the manure kind, prepared by incorporating different oily materials with those of other kinds. It has been highly extolled by some cultivators, while others have thought less favourably of its properties. It is probable, however, that the expence of articles of this nature must render their use very limited in most situations.

But on the supposition that oil rendered miscible with water, constitutes the chief nourishment of vegetables, and affords their principal support; Dr. Hunter of York proposed the following oil-compost.

	£.	s.	d.
Take North American pot-ash 12lb.	0	4	0
Break the salt into small pieces, and put it into a convenient vessel with four gallons of water. Let the mixture stand forty-eight hours, then add coarse train-oil, 14 gallons	0	14	0
	0	18	0

It may be noticed, that in a few days the salt will be dissolved, and the mixture, upon stirring, become nearly uniform. Then take fourteen bushels of sand, or twenty of dry mould. Upon these pour the above liquid ingredients. Turn this composition frequently over, after adding to it as much fresh horse-dung as will bring on heat and fermentation: in six months it will be fit for use. And it is apprehended, that the above quantity will be found sufficient for an acre; his trials, however, do not give him sufficient authority to determine upon this point. But for the convenience of carriage, he has directed no more earth to be used than will effectually take up the liquid ingredients. However, if the farmer chooses to mix up the compost with the mould of his field, he would advise him to use a larger portion of earth, as he will thereby be enabled to distribute it with more regularity upon the surface. He has not yet had any extensive trial of its efficacy upon pasture and meadow grounds; but he presumes, that whatever will nourish corn, will also feed the roots of grass. When used upon such lands, it should be put on during a rainy season, as all top-dressings are injured by the solar heat, and all kinds of cattle must be kept off the lands for some time, as they will bite the grass too close in quest of the salt contained in the compost, which he has found to be the case in small trials.

It is added, that the oil-compost is only intended to supply the place of rape-dust, soot, woollen rags, and other

expenſive hand-dreſſings. It is in all reſpects inferior to rotten dung: where that can be obtained, every kind of manure muſt give place to it. But at the ſame time that dung affords nouriſhment, it opens the pores of the earth. Hand-dreſſings, on the contrary, give food to plants, but contribute little towards looſening the ſoil. This is an uſeful and practical diſtinction, and may be applied through all the variety of manures made uſe of by the farmer. And it is preſumed, that the oil-compoſt reſembles the natural food of plants; but he ſubmits that, as well as every thing elſe, to experience our unerring guide. It may be objected, that it has not ſufficiently undergone the putrid ferment, to attenuate the oily particles. The uſe of rape-duſt, ſoot, horn ſhavings, and woollen rags, takes off that objection, and at the ſame time confirms the theory upon which the above compoſt is founded. But he does not take upon him to direct the experienced farmer in the manner of uſing this new compoſt. He would have every perſon apply it in the way moſt agreeable to himſelf. Many things will occur to the practical huſbandman, that no reaſoning of the philoſopher could foreſee. By attending to the different ways of uſing it, we may, it is ſuppoſed, reap conſiderable advantages. Improvements may be collected even from the higheſt degree of miſmanagement. And facts muſt ever be the foundation of our reaſoning. Without them, the philoſopher is a kind of *ignis fatuus*. Inſtead of unfolding nature, he covers her with a cloud, and endeavours, as it were, to bring old chaos back again into the world. If, however, he ſhould preſume to inſtruct the farmer in the management of the compoſt, he would recommend it to be ſown immediately after the grain, and both harrowed in together.

The following experiment is ſtated, which, though trifling in its own nature, gave him the firſt encouragement to proſecute the ſubject upon a larger ſcale. He took four pots, Nos. 1, 2, 3, 4.

"No. 1. contained 12lb. of barren ſand, with 1 oz. of the ſand oil-compoſt.

"No. 2. contained 12lb. of ſand without any mixture.

"No. 3. contained 12lb. of ſand, with ½ oz. of flaked lime.

"No. 4. contained 12lb. of ſand, with 4 oz. of the ſand oil-compoſt."

And in the month of March he put ſix grains of wheat into each pot, and during the ſummer occaſionally watered the plants with filtered water. All the time that the plants were conſuming the farina, he could obſerve but little difference in their appearance. But after one month's growth, he remarked that No. 1. was the beſt; No. 2. the next; No. 3. the next; No. 4. much the worſt. And in Auguſt he made the following obſervations: No. 1. had five ſmall ears, which contained a few poor grains. No. 2. had three ſmall ears, containing a few grains, much inferior in goodneſs to the former. No. 3. had no ears. Only he obſerved two very ſmall ones within their reſpective ſheaths, which for want of vegetable ſtrength never made their appearance. No. 4. had no ears; the ſtalks appeared ſtunted in their growth.

"He then removed the plants from their pots, and took a view of the roots of each.

"No. 1. The roots tolerably large, and well ſpread.

"No. 2. The roots not ſo large.

"No. 3. The roots very ſhort and ſmall.

"No. 4. The roots much the ſhorteſt, with the appearance of being ricketty."

Upon this experiment it is ſuggeſted,

"1. That the oil-compoſt may be conſidered as a vegetable food; but that, when uſed too liberally, the alkaline ſalt will burn up the roots of the plant, and hinder vegetation. For which reaſon he would recommend the compoſt to be expoſed to the influence of the air for ſome months, before it is laid on. 2. That lime contains no vegetable food, and is, in its own nature, an enemy to vegetation. It is, however, of excellent uſe in aſſiſting vegetation."

Theſe experiments teach him, that all kinds of ſoils may be benefited by this manure. The limeſtone, gravelly, ſandy, and chalky ſoils ſeem to require it moſt. The rich loams and good clays have nouriſhment within themſelves, and ſtand more in need of the plough than the dung-hill. And it is noticed, that it is obſerved by farmers, that rape-duſt ſeldom ſucceeds with ſpring-corn, unleſs plentiful rains fall within a few weeks after ſowing. He has more than once made the ſame obſervation upon the oil-compoſt, which induces him to recommend it for winter crops only. From the unctuouſneſs of its nature, it is more than probable, that it ſhould lie expoſed for a long time to the influence of the weather, which benefit it is deprived of when uſed for barley, and ſuch crops as are ſown late in the ſpring. He is confirmed in this idea, from repeated experiments made with the compoſt upon turnips, which generally proved unſucceſsful. And at the ſame time he invariably found that thoſe parts of the field on which the compoſt had been ſpread produced the beſt crops of grain the following year. From this ſlow manner of giving its virtues, it ſeems to be an improper dreſſing for all plants that have a quick vegetation.

On the whole it is concluded, that the oil-compoſt, as it plentifully reſtores particles of the oily kind, ſimilar to thoſe that are carried off, has a fair appearance of proving an excellent reſtorative.

The following experiments in ſupport of the utility of this ſort of manure are ſtated. In the month of June he ſelected four lands of equal goodneſs in a field intended for turnips. The ſoil was a light ſand, with a ſmall portion of vegetable earth amongſt it. It was ploughed out of ſward in November, and had not borne a crop for many years. He diſtinguiſhed his experimental lands by Nos. 1, 2, 3, 4.

No. 1. was manured with rotten dung.

No. 2. with oil-compoſt.

No. 3. with lime.

No. 4. was left without any dreſſing.

On the 20th of June they were all ſown with turnip-ſeed, broadcaſt, and during the courſe of the ſeaſon were twice hoed.

"In November he viewed the field, and made the following remarks:

N° 1—the beſt.
2—the next.
3—the worſt.
4—better than N° 3.

"Here he ſuppoſes the oil-compoſt appears in a favourable light; but other trials, made with equal accuracy, ſeem rather to prove that it is not proper for turnips, barley, or quick growing vegetables. It requires being meliorated by the action of the atmoſphere, and therefore is better adapted to winter crops." But by repeated experiments made ſince he firſt brought forward this manure, he is "convinced that the addition of an alkaline ſalt is not ſufficient to alter the nature of ſoil, ſo as to make it fully capable of entering in to the roots of plants in its native form: but when decompoſed by the mixture of freſh dung, he is convinced that it then becomes the true pabulum of plants."

It is ſuppoſed that "when the land happens to be ſtiffer than is required for turnips, it may be good huſbandry to lay upon it a large quantity of lime to open its body for the free admiſſion of the tap-root of the turnip. The lands will

alſo be rendered more dry, without which the turnips will never arrive at any ſize. Farmers, in general, take great pains to pulverize their light ſoils intended for turnips; but they ſeldom plough deep enough. A turnip is found to root deep, and in all operations of huſbandry we ſhould be careful to follow the bias of nature. It is for that reaſon we ought to make ourſelves acquainted with the ſize and the ſhape of the roots of ſuch plants as are the objects of field huſbandry: when once we have obtained that neceſſary knowledge, it will be an eaſy matter to ſuit the preparation of the ſoil to the nature of the grain. It will alſo enable us to direct the variations of our crops upon juſt and rational principles."

But in Mr. Stovin's trials with oil-compoſt in 1769, the reſults were theſe:

	£	s.	d.	Produce. Q.	B.	P.
"One acre, ſown with barley, and manured with oil-compoſt -	0	18	0	5	5	0
"One acre adjoining, ſown with barley, and manured with rotten dung, twelve loads, worth -				4	3	
Difference				1	1	2

And the compoſt barley was bolder and better corn than the other. In the year 1770, the dunged acre produced of rye, three quarters. The compoſt acre, of ditto, two quarters ſix buſhels. And in the year 1771, the ſame lands were ſown with oats, and the produce was greatly in favour of the dunged acre. This laſt experiment, being contrary to the idea of good huſbandry, was made with a view to determine the abſolute ſtrength of the compoſt. All top-dreſſings are exhauſted in the year. The oil-compoſt ſeems to retain its vigour longer. It will here be proper to obſerve, that theſe experimental lands were in a common field, which had been many years under the plough.

Alſo in Mr. Townley's experiments, they were as below. "In the ſpring of 1770, he prepared a piece of ground for onions. It was laid out into ſix beds of equal ſize, and all ſown at the ſame time.

"Over two of them, the oil-compoſt was ſcattered in a very moderate quantity; over the other two, pigeon-dung; and over the remaining two, ſome of his weed-compoſt, which he eſteems one of the beſt manures, for moſt vegetables, that can be made." It is compoſed of vegetable ſubſtances reduced into a putrid ſtate. "The onions came up very well in all the beds; but, in about ſix weeks, thoſe that were fed with the oil-compoſt plainly diſtinguiſhed the advantage they had over the reſt, by their luxuriancy and colour; and at the end of the ſummer perfected the fineſt crop that he had ever ſeen, being greatly ſuperior to the others both in quantity and ſize."

In another experiment with it in this crop, his ſucceſs was ſtill much greater though the ſoil was worn out. The oil-compoſt was uſed as a top-dreſſing after the crop was ſown. "The ſame ſpring he made an experiment upon four rows of cabbages, ſet at the diſtance of four feet every way. Two were manured with the oil-compoſt, and two with his own. All the plants were unluckily damaged, juſt before they began to form, by ſome turkies getting into the field, and plucking off the greateſt part of the leaves. However, they ſo far recovered as to weigh, in the September following, from 22lbs. to 28lbs. a-piece. The rows proved ſo equal in goodneſs that he could not determine which had the advantage."

And "the ſame year one part of a field of wheat expoſed to the north-eaſt winds, which that ſpring continued to blow for a month or five weeks, appeared very poor and languid at the time of tillering. Over it he ordered ſome of the oil-compoſt to be ſown with the hand, which not only recovered, but alſo puſhed forwards the wheat plants in that part of the field, ſo as to make them little inferior, if any, to the reſt."

The ſame ſpring he "made a comparative experiment upon four contiguous lands of oats, between the oil-compoſt and his own weed-compoſt. The latter had manifeſtly the advantage, though the other produced a very fine and large crop. He alſo tried the oil-compoſt upon carrots, and it anſwered exceedingly well. He did the ſame this year (1771), both upon them and his onions; and has the fineſt crops of thoſe vegetables he ever ſaw any where upon the ſame compaſs of ground."

Mr. Roebuck, in trying this manure in gardening, planted twelve alleys, that lay between his aſparagus beds, with cauliflower plants; each alley took up about thirty plants. One of the alleys he ſet apart for an experiment with the oil-compoſt, prepared as above.

"About a handful of the compoſt was put to the root of each cauliflower plant. In all other reſpects the alley was managed like the reſt. The plants in general flowered very well; but thoſe to which he applied the compoſt, ſprung up haſtily with ſmall ſtalks, and produced very poor flowers. He imputed this unfavourable appearance to the freſhneſs of the compoſt, which was only a few weeks old. In all future trials, he intends to expoſe it to the action of the air, in order to abate the heat, and neutraliſe the acrimony of the ſalt."

But "in the September following this unſucceſsful experiment, he planted the ſame alleys with early cabbages. The neceſſity of meliorating the compoſt was in this trial fully confirmed. For the cabbages that grew upon the alley, which in May had received the compoſt, were larger, and in all reſpects finer, than the others. The idea that he entertains of the compoſt is, that when meliorated in the earth, it is capable of giving a richneſs and freſhneſs to it. Upon this principle he would recommend it to gardeners as a ſubject worthy of further trials.

Although theſe experiments ſufficiently ſhew, that ſubſtances of this ſort may be uſed with advantage in the way of manures, their expence muſt in moſt caſes prevent their being made uſe of to any great extent.

Oil-*Manure*, ſuch as is conſtituted of oil with other materials. The compoſition of a manure of this kind, which has been ſaid to be highly beneficial, with the expence for one acre of land in 1792, is thus ſtated:

	£	s.	d.
Rape or train-oil ſix gallons, at 2*s.* 6*d.* - -	0	15	0
Sea-ſand ſix buſhels, at 2*d.* - -	0	1	0
Coarſe ſalt two buſhels, at 1*s.* - -	0	2	0
Malt coombs 24 buſhels, at 4½*d.* - -	0	9	0
	1	7	0

In the preparation of which, it is adviſed to ſpread the coombs on the floor about four inches thick, then to ſprinkle the ſalt as level as poſſible, throwing on half the quantity of ſand and half the quantity of oil out of a watering-pot, turning it and raking it well, afterwards to add the reſt of the oil and ſand as before, turning it well till thoroughly mixed, and then throw the whole into a heap for uſe. On this it is ſuggeſted, that as the prolific quality of oil-cake is only in proportion to the oil it contains, this compoſition muſt be preferable, having a much greater quantity of oil

in it; and as malt coombs are a manure of themſelves, eſpecially for turnip land, at about eighty or ninety buſhels *per* acre, he dares venture to aſſert, that twenty-four buſhels with the addition of oil is equal to the above quantity, or even to the twelve loads of muck. The ſand and ſalt mixed with it, not only occaſion it to imbibe the oil more freely, but likewiſe give it a better body for the conveniency of ſpreading on the land. And though ſome may think the quantity of ſalt is too little, he is convinced of the contrary, having found by experience that a ton or even a ton and a half has not anſwered ſo well as three or four hundred. The caſe is very ſimilar with regard to lands near the ſalt marſhes, where the tide ſometimes overflows them, and it is well known by thoſe who occupy ſuch lands that nothing will grow for three or four years, but afterwards they become very fertile. The reaſon he ſhall not take upon himſelf to give, but he has found it ſo by his own experience. The writer concludes by obſerving, that ſome farmers have uſed only half the above quantity *per* acre, notwithſtanding which they had good crops. But it has been obſerved that the extra expence makes againſt its becoming generally uſeful from the great price of oil, and the expence of the carriage of ſea ſand and droſs ſalt, in moſt inland ſituations. See OIL-*Compoſt*.

OIL-*Paint*, in *Rural Economy*, that ſort of paint which is compoſed of oil, and the oxyd of lead, or ſome other ſimilar ſubſtance, to form its baſis, or give it a body, and which is uſed for various farm purpoſes.

But the great expence of paints of this ſort has led lately to the introduction of many other materials, for the protection of wood work, and boarding of different kinds, ſuch as preparations from foſſil coal, &c. But a great objection to all theſe ſubſtances, beſides their expence, is the highly diſagreeable ſmell that they afford, and their liability to crack and bliſter.

In caſes where oil painting cannot be had recourſe to, either becauſe it does not dry ſoon enough, and has an inſupportable ſmell, or becauſe it is too dear; the following method has been employed by Mr. Ludicke for painting ceilings, gates, doors, and even furniture, with great ſucceſs: it is thus prepared, take freſh curds, and bruiſe the lumps on a grinding-ſtone, or in an earthen pan, or mortar, with a ſpatula. After this put them in a pot with an equal quantity of lime, well quenched, and become thick enough to be kneaded; ſtir this mixture well without adding water, and a white coloured fluid will ſoon be obtained, which may be applied with as much facility as varniſh, and which dries very ſpeedily. It muſt, however, be employed the ſame day, as it will become too thick the next day. And with this ochre, armenian bole, and all colours which hold with lime, may be mixed according to the colour which is wiſhed to be given to the wood; but care muſt be taken that the addition of colour made to the firſt mixture of curds and lime contain very little water, otherwiſe the painting will be leſs durable.

In performing the work, after two coats of this paint have been applied, it may be poliſhed with a piece of woollen cloth, or other proper ſubſtance, and will become as bright as varniſh.

It is aſſerted that this paint, beſides being cheap, has other advantages; in the ſame day two coats may be laid on and poliſhed, as it dries ſpeedily, and has no ſmell. If it be required to give it more durability in places expoſed to moiſture, it may be done after it has been poliſhed with the white of an egg; which is ſaid to render it as durable as the beſt oil painting that can be employed. And another ſubſtitute that may be uſed for painting weather boarding is prepared by taking three parts air-ſlaked lime, two of wood-aſhes, and one of fine ſand or ſea-coal aſhes, ſifting them through a fine ſieve, and then adding as much linſeed oil as will bring it to a conſiſtence for working with a painting bruſh: great care muſt be taken to mix it perfectly. It is impenetrable to water, and the ſun hardens it, and renders it a great preſerver of the wood.

Another compoſition has likewiſe been made uſe of with great benefit to paint boards, &c. which is made in this way. Melt twelve ounces of roſin in an iron pot, adding three gallons of train oil, and three or four rolls of brimſtone; when melted thin, as much Spaniſh brown ochre firſt ground fine with as much of the oil as will give the colour, ſhould be added; it ſhould be laid on with a bruſh as hot and as thin as poſſible, and ſome days after the firſt coat is dry another applied. It will preſerve planks for a very great length of time, as well as other ſubſtances.

The kinds of oils, their properties, manners of expreſſion, &c. are numerous: for the generality of them, the reader is referred to the proper articles.

Such as could not be more conveniently inſerted, are as follow.

OIL *of the Almond*, in the *Materia Medica*, is obtained either from the ſweet or the bitter almond, that from the one or the other being equally free from bitterneſs. The almonds are put into a coarſe hempen or hair ſack, and ſhaken violently, in order to detach, by friction with one another and againſt the ſides of the ſack, the outer-brown ſkin, which is apt to give a bitter taſte to the oil: they are then bruiſed and made into a paſte, and preſſed in the uſual manner. The London college directs the almonds to be macerated in cold water for 12 hours, and then bruiſed; and the oil is afterwards to be expreſſed without heat. The Edinburgh college orders any quantity of almonds to be bruiſed in a ſtone-mortar, and then put into a hempen ſack; the oil is to be expreſſed without heat. The Dublin college prepares this oil by bruiſing the freſh almonds in a mortar, and expreſſing it by a preſs, without heat. Sixteen ounces of almonds yield about five ounces of a bland inodorous oil, of a very ſlightly ſweetiſh taſte, which is at firſt turbid, but ſoon becomes clear. About ℥iii more may be obtained by impregnating the marc with the ſteam of boiling water. The colour of this oil is very pale greeniſh-yellow, and its ſpecific gravity .932, Fabroni; .917, Aikin. The degree at which it congeals is variouſly ſtated at 19° Fahr. and 8° Fahr. It is ſaid that the oil from the bitter almond keeps longer without growing rancid than that from the ſweet almond. This oil is demulcent and emollient, and uſed in coughs and other pulmonary complaints united with water by means of mucilage, or the yolk of egg and ſugar. A mixture of f.℥iv of almond oil, ♏ viii of acetate of lead, forms an uſeful injection at the commencement of gonorrhœa. The doſe of the oil is from f.ʒiv to f℥j. See ALMOND.

OIL *of Amber* of the London college is obtained by putting the amber into an alembic, and diſtilling from a ſand-bath, with a fire gradually raiſed, an acid liquor, the oil, and a ſalt impregnated with the oil; then re-diſtilling the oil twice.

The *purified* oil of amber of the Edinb. diſpenſatory is had by diſtilling oil of amber, mixed with ſix times its weight of water, from a glaſs retort, until two-thirds of the water have paſſed into the receiver; then ſeparating this purified volatile oil from the water, and keeping it in well ſtopped veſſels.

The *rectified* oil of amber of the Dublin pharmacopeia is prepared by taking a pound of the oil which comes over in the preparation of ſuccinic acid, and ſix pints of water, and

diſtilling until two-thirds of the water have paſſed into the receiver, and ſeparating the oil. This oil is of a dark colour, thick conſiſtence, and fœtid odour; but by ſucceſſive diſtillations, it is rendered thinner, of a lighter colour, and at length nearly limpid. Rectified oil of amber has a ſtrong ungrateful odour, and a hot acrid taſte. It is light, volatile, and inflammable, inſoluble in water, and only partially ſoluble in alcohol. As to its medical properties, it is ſtimulant, antiſpaſmodic, and rubefacient. It has been found ſerviceable in deficient menſtruation, and in hyſteria, epilepſy, and ſome other convulſive affections; but it is now ſcarcely ever uſed as an internal remedy. The doſe may be from ♏ v to ♏ xij, combined by means of mucilage with any diſtilled water. It is more generally employed as a rubefacient in rheumatiſm and paralyſis; and a mixture of f.℥j of this oil with f.℥ſs of tincture of opium, has been found beneficial as a friction to the affected part in tic douloureux; and in hooping-cough, rubbed upon the cheſt two or three times a day. The officinal preparation is the SPIRITUS *Ammoniæ Succinatus* of the London college. See AMBER and SUCCINIC *Acid.*

OILS, *Animal*, in general, are thoſe that are obtained from animal ſubſtances, either in the ſtate of butter and fat, uncombined with the other principles of animal matters; of which kind are fat, marrow, the expreſſed oils of yolks of eggs, ſpermacceti, &c. Or, in a ſtate of combination, afforded by diſtillation of the gelatinous ſubſtance, which forms almoſt entirely all the parts compoſing animal bodies, as fleſh, tendons, nerves, cartilages, bones, horns, hair, &c. See OIL, *ſupra.*

OIL, *Animal*, *Oleum Animale*, in a more reſtricted ſenſe, the name of an eſſential oil diſtilled by a retort from blood, and formerly recommended as a powerful internal remedy in epilepſies, the gout, and other obſtinate diſeaſes.

It was originally uſed in Germany in theſe intentions. As an external, it may probably be of good ſervice in removing fixed pains, hard tumours, &c. for it is extremely penetrating.

OIL, *Volatile*, *Animal*, or *Dippel's oil.* (See DIPPEL'S *Oil.*) If albumen or gluten be diſtilled at a dry heat, there ariſes, together with the ammonia and carburetted hydrogen, a quantity of fœtid black oil, which was the ſubject of various experiments, firſt by Dippel, a chemiſt of Berlin, and afterwards by Rouelle. From the concurrent labours of the enquirers, it appears that if this oil is rectified by three ſucceſſive diſtillations from the ſurface of water, it becomes at length quite colourleſs and tranſparent; its odour is powerful, but ſomewhat aromatic, and it is nearly as light and volatile as ether. It contains a little ammonia, and hence changes the colour of ſyrup of violets green; it is ſparingly ſoluble in water, and largely ſo in oils, ether, and alcohols. It combines both with acids and alkalies into imperfect ſoaps; it is very inflammable, and, like the vegetable eſſential oils, may be ſet on fire by ſtrong nitrous acid. If expoſed even to the light, it is partly decompoſed, loſing its tranſparency, and becoming of a brown colour. It was formerly employed in medicine; but is now wholly diſuſed. Aikin's Dict.

OIL *of Aniſe-ſeed.* (See ANISE-SEED.) This oil is given as a carminative, and for relieving flatulence in children, from ♏ v to ♏ xv triturated with ſugar. The officicinal preparations are tinctura opii ammoniata of the Edinburgh college, and tinctura opii camphorata of the Dublin college. See TINCTURE.

OIL *of Antimony*, a name given to the butter of antimony, and ſome other ſolutions of antimony by acids. See ANTIMONY.

OIL *of Arſenic.* See ARSENIC.

OIL *of Aſpic*, or *Spike.* See SPIKE.

OIL *of Balm.* See BALSAM and MELISSA.

OIL *of Bays* is an eſſential oil, obtained from the berries of the bay, or LAURUS *Nobilis.* Theſe berries give out to the preſs an almoſt inſipid fluid oil; and on being boiled in water, a thicker butyraceous one, of a yellowiſh-green colour, impregnated with the flavour of the berry. The berries and leaves of the bay are accounted ſtomachic, carminative, and uterine: with this view, infuſions of the leaves are drank as tea, and the eſſential oil of the berries is given on ſugar, or diſſolved by means of mucilages, or in ſpirit of wine, from one to five or ſix drops. But the principal uſe of theſe ſimples in the preſent practice is external: they are made ingredients in carminative glyſters, warm cataplaſms, and uterine baths; and the butyraceous oil of the berries ſerves as a baſis for ſome nervine liniments, and mercurial and ſulphureous unguents. Lewis. See DAPHNE-LÆON.

OIL *of Beech*, See BEECH-*oil.*

OIL *of Been*, or *Ben.* See BEN.

OIL, *Birch*, a vegetable empyreumatic oil, prepared in Ruſſia, by charring birch-wood in a cloſe oven, the watery acid and oil being collected in a large receiver; and the latter product being the lighteſt, is ſkimmed off from the ſurface of the water. This oil has a peculiar ſcent, and is ſaid to drive away worms and other inſects; on which account it is uſed in the dreſſing of Ruſſia leather, to which it communicates thoſe properties that render it ſo much eſteemed by the binders of books.

OIL, *Britiſh*, an empirical medicine of the ſame nature with the petrolea; the genuine ſort being extracted by diſtillation from a hard bitumen, or a kind of ſtone-coal, found in Shropſhire, and other parts of England. Lewis.

OIL, or *Butter*, of *Cacao.* See COCOS.

OIL, *Cajeput.* See CAJEPUT and MELALEUCA.

OIL *of Camphor.* See CAMPHOR and LAURUS.

OIL *of Caraway.* (See CARUA.) Six pounds of caraway-ſeeds yield $4\frac{1}{2}$ ounces of oil, which has an aromatic odour, and a ſweetiſh pungent taſte; it is viſcid, and of a yellow colour; its ſpecific gravity is .946. This oil, which is ſtimulant and carminative, is chiefly uſed as an adjunct to purgative pills, and for covering the diſagreeable flavour of other ſubſtances. The doſe is from ♏ j to ♏ x. The officinal preparations are electuarium ſennæ, confectio ſcammonii, pilulæ aloes comp., and pilulæ aloes, cum myrrha.

OIL *of Caſtor.* See CASTOR and RICINUS.

OIL, *Cardamom.* See CARDAMOM.

OIL, *Cauſtic.* See ARSENIC.

OIL *of Chamomile*, an oil diſtilled from anthemis or chamomile. Its odour is unpleaſant, and its taſte pungent. When recently diſtilled, its colour is a cerulean blue, which changes by age to a deep yellow. Eighty-two pounds of chamomile-flowers yield 18 drams of oil. This oil is ſuppoſed to poſſeſs antiſpaſmodic powers, and is therefore ſometimes recommended in cramp of the ſtomach, and as an adjunct to purgative pills. The doſe is from ♏ v to ♏ x, but it is ſeldom uſed. See ANTHEMIS.

OIL *of Cinnamon.* See CINNAMON.

OIL *of Cloves.* See CARYOPHYLLUS.

OIL *of Cole-Seed.* See COLE-*Seed.*

This oil, and alſo thoſe of muſtard-ſeed, rape-ſeed, and ſunflower-ſeed, are leſs coloured and leſs highly flavoured than thoſe of linſeed and hemp-ſeed. They are very little liable to dry by expoſure to the air; and theſe circumſtances, together with their moderate price, induce a large conſumption of them by the wool-dreſſers, in order to pre-

ſerve the wool from the attacks of moths and other inſects; and alſo by the leather-dreſſers.

Oil, *Connecting*, a term uſed by Boerhaave, and his followers, to expreſs a certain oil, found in all vegetable ſubſtances, but wholly different from, and independent of, their eſſential oil. This is not poſſeſſed of any of their virtues or qualities, but ſeems the ſame in all plants, and is the means of their conſiſtence and ſolidity, giving tenacity to their earth, which, without it, falls to duſt, and the plant exiſts no more.

This oil is not ſeparable by boiling water, as the eſſential oil is, but only by fire: when a plant has been boiled and diſtilled, its eſſential oil, ſalt, &c. are all carried off, and what remains is only the earth corrected by this oil. This being expoſed to the fire, the oil diſcovers itſelf in a thick, black, ſtinking ſmoak, and, finally, taking fire, it burns away, and leaves only the earth, which was the baſis of the plant; retaining its form, indeed, if the proceſs has been carefully made, but falling into a ſhapeleſs powder only on being roughly breathed upon.

This great author, therefore, eſtabliſhes it as a rule, that there are three ſorts of oil in plants. 1. An oily froth. 2. The eſſential oil, diſſolved in decoction. And, 3. This connecting, or conſolidating oil, ſeparable only by a naked fire.

Oil, *Cornel*, a fixed oil reſembling olive oil, by being contained, not in the ſeed, but in the pulpy fruit of the vegetable. The berries of this ſhrub (Cornus *Sanguinea*) being collected when quite ripe, and laid in heaps for a few days to mellow, are to be reduced to a pulp, and preſſed without heat in the uſual manner. By this treatment, from 22lbs. avoirdupois may be obtained ſomewhat more than four wine pints of a fat, ſomewhat viſcid, oil, of a bright green colour, and equally deſtitute of any unpleaſant flavour as the beſt olive oil. When heated with nitric acid, it is converted to a brown-yellow butter or wax. By boiling with litharge, it becomes drying; when ſpread thin on water, and expoſed to the air for a month, it is converted into a white wax. It does not freeze ſo readily as olive oil, and laſts rather longer than this when uſed in a lamp. Aikin's Dict.

Oil *of Cumin*. See Cuminum.

Oil *of Dill*. See Anethum.

Oils, *Drying*. See Oil, *ſupra*.

Drying oils are formed of linſeed oil, prepared by means of boiling, ſometimes with and ſometimes without the addition of other ſubſtances. Thoſe commonly added to oil, in this preparation, are white vitriol, ſugar of lead, ſeed-lac, gum maſtic, gum ſandarac, gum animé, gum copal, umbre, colcothar, litharge, and red-lead. A drying oil for the nicer works may be prepared by boiling two ounces of gum ſandarac, white vitriol, and ſugar of lead, of each one ounce in a pint of nut or poppy oil, till the ſolid ingredients be diſſolved, and the mixture becomes of the colour of linſeed oil. For coarſer work, take one gallon of linſeed oil, one pound of litharge of gold or ſilver, half a pound of white vitriol, and ſugar of lead, gum arabic, and umbre, of each a quarter of a pound; boil them as long as the diſcolouring of the oil, which is the gradual conſequence of boiling, will allow. That made for ſale is prepared by boiling one gallon of linſeed oil, and one pound and a half of red-lead, as long as the colour will bear it. When the calxes of lead are united in ſmall quantity with oil, they diminiſh its fluidity, and diſpoſe it to dry more readily. Theſe oils are much uſed in painting, on account of their drying quality. When a large quantity of calxes of lead is combined with oil, they form with it a ſolid, opaque, and tenacious body, capable of ſoftening by heat. Theſe combinations are uſeful in pharmacy, for giving a convenient conſiſtence and tenacity to many plaſters.

Oils, *Diſtilled*, are the volatile oils, ſo called in the London pharmacopœia. For preparing them, they direct that the ſeeds of aniſe and caraway, the flowers of chamomile and lavender, the berries of juniper and all-ſpice, the tops of roſemary, and the entire plants of the other articles, dried, are to be employed. Any one of theſe is put into an alembic, and as much water poured in as will cover it; and then the oil is diſtilled into a large refrigeratory. The water which diſtils over with the oils of pepper-mint, ſpear-mint, all-ſpice, and penny-royal, is to be preſerved for uſe.

Oil *of the Earth*, *Oleum Terræ*, in the *Materia Medica*, the name of a thick mineral fluid of a duſky browniſh-black, with a faint caſt of purple, and of the conſiſtence of a thin ſyrup, very little tranſparent, and of a ſtrong penetrating ſmell, like that of common oil of amber. It oozes out of the cracks of rocks, in ſeveral parts of the iſland of Sumatra, and ſome other parts of the Eaſt Indies, and is much eſteemed there in paralytic diſorders; but it is ſeldom imported into England; what our Eaſt India ſurgeons and captains uſually bring over under this name being only a vegetable oil, impregnated with the virtues of certain of their foſſils by boiling. See Petrol.

Oil, *Empyreumatic*. See Oil, *ſupra*, and Empyreuma.

Oils, *Eſſential*, are thoſe which have evidently the ſmell of the vegetable from which they are obtained. All theſe oils are ſufficiently volatile to riſe with the heat of boiling water; and this degree of volatility is one of their ſpecific characters. See Oil, *ſupra*.

The oils of plants have not always the ſame taſtes with the plant they are diſtilled from, or, at leaſt, not in the ſame degree. Nothing is more bitter than wormwood, yet the oil of wormwood has no remarkable bitterneſs. Aniſe, which is of a ſweet taſte, yields, on the contrary, an oil infinitely more ſweet than the ſeed; and pepper, which is ſo remarkably hot and acrid, affords an oil no way remarkable for its pungency. Thyme, which is in itſelf very acrid and pungent, conveys that property, in a yet greater degree, to its oil; there is, indeed, no eſſential oil ſo acrid and fiery as that of this plant. The fetid oils drawn in dry diſtillation by the retort, in an open fire, no way differ from theſe but by the damage the fire has done them, and may always be converted into theſe by repeated diſtillations. Nay, the very fat oils, ſuch as that of almonds, may be attenuated ſo far as to become as fine, and as ſubtile, as the eſſential oils. This is to be done by means of quick-lime; and ſeveral repeated diſtillations of this oil, or any other of a like kind, with freſh lime to every diſtillation, will reduce it to be volatile, penetrating, and capable of being raiſed, and diſtilled, by means of water, which is the greateſt teſt of the eſſential oils. The bituminous and fetid oils may alſo, in the ſame manner, be reduced, by repeated diſtillations, to the ſtate of the eſſential ones, and to be equally fluid and limpid, and equally penetrating. Memoirs Acad. Par. 1721.

The eſſential oils of vegetables may be divided into two claſſes, according to their different ſpecific gravities, ſome floating upon water, and others readily ſinking to the bottom thereof. Thus the eſſential oils of cloves, cinnamon, and ſaſſafras, readily ſink; but the oils of lavender, marjoram, mint, &c. ſwim upon the water. The lighteſt of all the eſſential oils is, perhaps, that of citron peels, which even floats on ſpirit of wine; and the heavieſt of them ſeems to be the oil of ſaſſafras.

For the obtaining the full quantity of the more ponderous

oils from cinnamon, cloves, saffafras, &c. it is proper 1. To reduce the subjects to fine powder. 2. To digest this powder for some days in a warm place, with thrice its quantity of soft river water made very saline with the addition of sea-salt, or sharp with oil of vitriol. 3. To use the decoction left in the still, instead of common water, for a fresh digestion. 4. To use also, for the same purpose, the water of the second running, after it has been cleared of its oil. 5. Not to distil from too large a quantity of the subject at once. 6. To leave a considerable part of the still empty. 7. To use a brisk fire, or a strong boiling heat at first, but to slacken it a little afterwards. 8. To have a low still head, with a proper internal lodge, and current, leading to the nose of the worm. And, 9. To cohobate the water, or pour it back upon the matter in the still, after separating its oil, and repeating this once or twice more.

The vegetable world affords vast variety of essential oils, most of them very odorous, and of great virtues; but different vegetables yield oils of different consistence, and in different quantities.

These oils are employed in painting, in spirituous liquors used at the table and at the toilette, in perfumes, and in medicine. As they act very powerfully, small doses, as from one drop to four or five, incorporated with sugar, must be given internally. They are recommended as cephalic and antispasmodic, in convulsive and hysterical affections: they are also stimulant, sudorific, and strengthening. All drugs which are alexipharmic, cephalic, tonic, and stomachic, containing vegetable aromatic, derive their virtues from the essential oils of these vegetables. The same may be said of all medicinal, aromatic, and spirituous waters. In some cases, essential oils are employed externally as strengtheners, and to allay painful spasms of nervous and tendinous parts, to resolve and dissipate acrid humours, which occasion pain, without any sensible inflammation; but they must not, on account of their caustic quality, be used alone, but formed into liniments or pomatums, by mixing them with a sufficient quantity of fat, or fat oils. When applied to the human body, they stimulate, corrode, and resist putrefaction; and mixed with the blood, raise some degree of fever. Med. Ess. Edinb. vol v. art. 24. See *Volatile* OILS, *infra*.

As many of the essential oils are dear, it is a very common practice to adulterate, or debase them several ways, so as to render them cheaper both to the seller and the buyer. These several ways seem reducible to three general kinds, each of which has its proper method of detection. These three ways are, 1. To adulterate them with expressed oils. 2. With alcohol. And, 3. With cheaper essential oils.

If any essential oil be adulterated with expressed oil, it is easy to discover the fraud by adding a little spirit of wine to a few drops of the suspected essential oil, and shaking them together; for the spirit will dissolve all the oil that is essential, or procured by distillation, and leave all the expressed oil that was mixed with it untouched.

If an essential oil be adulterated with alcohol, or rectified spirit of wine, it may be done in any proportion, up to that of an equal quantity, without being easily discoverable either by the smell, or taste. The way to discover this fraud is to drop a few drops of the oil into a glass of fair water; and if the oil be adulterated with spirit, the water will immediately turn milky, and by continuing to shake the glass, the whole quantity of spirit will be absorbed by the water, and leave the oil pure at top.

Finally, if an essential oil be adulterated by a cheaper essential oil, this is commonly done very artfully: the method is to put fir-wood, turpentine, or oil of turpentine, into the still, along with the herbs to be distilled for their oil, such as rosemary, lavender, origanum, &c.; and, by this means, the oil of turpentine distilled from these ingredients comes over in great quantity, and is intimately blended with the oil of the genuine ingredient. The oils thus adulterated always discover themselves in time, by their own flavour being overpowered by the turpentine smell; but the ready way to detect the fraud is to drench a piece of rag, or paper, in the oil, and hold it before the fire; for thus the grateful flavour of the plant will fly off, and leave the naked turpentine scent behind. Shaw's Lectures, p. 145.

The essential oils, as volatile oils are called by the Dublin college, are prepared in the following manner: let the oil be extracted by distillation from the substance previously macerated in water, as much water being added during the distillation as may be sufficient to prevent empyreuma. In distilling fennel, pepper-mint, spear-mint, penny-royal, and all-spice, the watery fluid that comes over in distillation with the oil is to be preserved for use.

OIL *of Fennel Seeds*. (See ANETHUM *Fœniculum*.) Seventy-five pounds of fennel seeds yield thirty ounces of oil, which is colourless, and congeals at 50°. It has the odour of the plant and a sweet taste. The specific gravity is .997. The medical properties and use are the same with those of the plant. The usual dose is from ♏ ij to ♏ xx; but it is rarely used.

OIL, *Fern*. See FERN.

OIL, *Granulated*, is that fixed in little grains; this is the best, and most esteemed, especially of oils of olives.

OIL, *Green*, *Oleum Viride*, a form of medicine prescribed in the late London pharmacopeia, and made in the following manner: take leaves of bay, rue, marjoram, sea-wormwood, and chamomile, each three ounces; oil of olives, a quart. Boil the herbs in the oil till they are crisp, and then strain off the oil; and when it has stood for the fæces to subside, put it up for use.

OIL *of Hartshorn, Rectified*, is prepared by the Dublin college in the following manner. Take of the oil which rises in the distillation of the volatile liquor of hartshorn, three pounds, and six pints of water. Distil the oil, then remix it with the water, and redistil, repeating the distillations until the oil becomes limpid. This oil should be kept in a dark place, in small phials completely filled and closely stopped.

This empyreumatic oil is first formed by the decomposition of animal matter by heat; and arises from a new combination of part of the hydrogen and carbon of the substance distilled. When first obtained, it is thick, of a dark colour, and has a very offensive odour; but by the rectification prescribed, it is rendered thinner and less offensive. The rectified oil is nearly colourless and transparent; it has a strong, slightly aromatic odour, and a penetrating taste. It is very light and volatile, strikes a green colour with syrup of violets, is partially soluble in water, and unites readily with alcohol, ether, and oils. The acids form with it a thick saponaceous compound; and with the alkalies it forms a fine soap. Exposure to light and air destroys its transparency, and gives it a deep brown colour. As to its medical properties and uses, this oil is stimulant, antispasmodic, anodyne, and sudorific. It was formerly regarded as a remedy of much efficacy in fever, administered a few hours before the accession of the paroxysm of intermittents; and was also much employed in epilepsy, hysteria, and all convulsive affections: but it is now almost discarded from practice, being only used occasionally as an external application to paralytic limbs. The dose may be from ♏ x to ♏ xxx, in a sufficient quantity of water. Thomson's Lond. Disp.

Oil, *Hempseed*, is of a green colour, and ſtrongly impregnated with the peculiar colour of this plant. The proportion of oil which hemp-ſeed affords is from 20 to 25 *per cent.* In its general properties, uſes, and mode of preparation, it very much reſembles linſeed oil; which ſee.

Oils, *Inflammability of.* See Oil, *ſupra.*

Oil *of Juniper*, or *of Juniper Berries.* (See Juniperus.) Forty-eight pounds of berries yield ſix ounces of oil, of a ſpecific gravity .611. In odour it reſembles turpentine, and its taſte is hot and acrid. It has a greeniſh-yellow colour, is viſcid, and depoſits a fæculent matter when long kept. When genuine it is ſoluble in alcohol. This oil is carminative, diaphoretic, and diuretic. It is ſometimes given in dropſy, and may be added to fox-glove, when it is exhibited in form of pills. The doſe is from ♏ ij to ♏ x, combined with water by means of ſugar or mucilage.

Oil *of Lavender.* (See Lavandula.) One pound and nine ounces of this oil are obtained from eighty pounds of lavender flowers. Its odour is very fragrant, and taſte warm and agreeable; its colour is a pale lemon-yellow, and ſpecific gravity .936. It is ſtimulant and cordial; and is chiefly uſed in hyſteria and nervous head-ache, in doſes from ♏ j to ♏ v, given on a lump of ſugar. Its officinal preparation is unguentum ſulphuris of the Edin. pharmacopeia.

Oil *of Lead*, is a ſolution of ſalt of lead in the eſſential oil of turpentine. This preparation is a powerful antiſeptic.

Oil *of Lemon*, called the eſſence of lemon. (See Lemon.) This eſſential oil is chiefly uſed as a perfume to cover the ſmell of ſulphur in ointments compounded with it. Its officinal preparations are ſpiritus ammoniæ aromaticus, unguentum ſulphuris, and unguentum veratri.

Oil *of Linſeed.* (See Linseed.) The ſeeds of the common flax, conſiſting of a white kernel covered with a thin browniſh ſhell, which cannot be ſeparated from it, are ſubmitted entire to the preſs; but if they are thus treated without any previous preparation, they yield a comparatively ſmall quantity of oil, on account of a ſtrong mucilage that reſides in the ſhell, and abſorbs a large proportion of the oil as it is forced out of the kernel. For this reaſon, and alſo becauſe the cold-drawn oil is not ſo fit for the purpoſes to which this oil is generally applied, the mucilage is deſtroyed before the application of the preſs by the following method. An iron-veſſel, like a ſand-bath, and capable of containing ſome buſhels, is fixed in a furnace; it is then filled with linſeed, and heated by a moderate fire, the contents being carefully ſtirred from time to time, that every part may be equally roaſted: at firſt there ariſes an abundance of aqueous vapour, which, as the heat is increaſed, is followed by denſe blackiſh fumes of a very nauſeous odour. When the torrefaction is completed, the paſte is preſſed in the mill in the uſual way. The proportion of oil yielded by this trial is about 20 *per cent.*; its ſpecific gravity is .9403: it is not congealed except by a cold below 0 Fahr., and its point of ebullition is about 600 of the ſame thermometer. The cold-drawn oil has a high yellow colour, is very unctuous and unpleaſant both to the taſte and ſmell: by expoſure to the air and light it becomes dry. The hot-drawn oil is of a high yellowiſh-red, or deep wine colour, and is more nauſeous than the former: it is of a thicker conſiſtence, and dries without much difficulty in the air, more eſpecially if it has been boiled with a little litharge. The great demand for this oil is in the coarſer kinds of painting, particularly ſuch as is not much expoſed to the weather, as floor-cloths, &c. In medicine it is conſidered as emollient, demulcent, and ſlightly laxative; but as an internal remedy it is ſeldom uſed, on account of its nauſeous taſte; though it has been given with advantage in ileus, when purgatives have failed. It is chiefly employed in the form of a glyſter, in flatulent colic attended with coſtiveneſs, and in abraſions of the rectum; and it is an uſeful application to burns, eſpecially when combined with lime-water. The doſe, when taken by the mouth, is from f.ʒſs f.℥j; but from f.℥iij to f.℥vj may be given at once, per anum. The officinal preparation is the linimentum aquæ calcis of the Edinburgh pharmacopeia, formed by mixing equal parts of linſeed oil and lime-water. Aikin. Thomſon.

Oil *of Mace.* See Mace and Nutmeg.

Oil *of Marjoram.* See Marjoram.

Oil, *Medullary.* See Medullary *Syſtem.*

Oil *of Mercury*, a ſolution of corroſive ſublimate in ſpirit of urine. See Mercury.

Oil *of Mint.* See Mentha.

Oil *of Muſtard.* See *Hedge* Mustard, and Sinapis.

Oil *of Myrrh.* See Myrrh.

Oil *of Nut.* (See Nut-*Oil.*) As the walnut and hazelnut from which this oil is obtained, chiefly by cold-drawing, come to their full perfection in the warm climate of the ſouth of Europe, they will yield, by proper management, full half their weight of oil. Recent cold-drawn nut-oil is preferred by many to olive-oil, on account of its retaining the exquiſite flavour of the nut; the hot-drawn has an empyreumatic taſte, and is no longer fit for the table: it is, however, much valued by the painter, as being eminently drying, much leſs coloured than linſeed oil, and capable of bearing the injuries of the weather better than any other oil.

Oil *of Nutmeg.* See Nutmeg.

Oil *of Olives* is the moſt popular, and moſt univerſal of all other; being that chiefly uſed in medicine, in foods, ſallads, and in the manufactures.

It is drawn from olives by preſſes or mills made for the purpoſe. The fruit is gathered when at its utmoſt maturity, in November, as it begins to redden: being put under the mill, as ſoon as gathered, care is taken that the mill-ſtones are ſet at ſuch a diſtance that they may not cruſh the nut of the olive. The fleſhy pulp, covering the nut or ſtone, and containing the oil in its cells, being thus prepared, is put into bags made of ruſhes, and moderately preſſed; and thus is obtained a conſiderable quantity of a greeniſh ſemi-tranſparent oil, which, from its ſuperior excellence, is called Virgin oil. The marc remaining after the firſt preſſure is broken to pieces, moiſtened with water, and returned to the preſs, upon which there flows out a mixture of oil and water, which ſpontaneouſly ſeparate by reſt. This oil, though inferior to the former, is of a good quality, and fit for the table. The marc, being again broken to pieces, well ſoaked in water, and fermented in large ciſterns, is again ſubmitted to the preſs, by which is obtained a very conſiderable quantity of a third kind of oil, that is very valuable to the ſoap-boiler and other manufacturers. In ſome countries, particularly in Spain, the olives, inſtead of being gathered by hand, are beaten down, ſo that the ripe and unripe ones are mixed together, and to theſe are added ſuch as have fallen of themſelves, and are therefore more or leſs decayed. All theſe are thrown together in a heap, which ſoon ferments: the olives in this ſtate are ground and preſſed, and thus is procured with leſs trouble a large quantity of oil, of a rank diſagreeable flavour, which none can bear but ſuch as have been accuſtomed to it from their childhood. Recently-drawn Virgin oil has a bland almoſt mucilaginous taſte, with a ſlight but

agreeable flavour: when exposed to the air, in an open bottle or cask, a white fibrous albuminous matter is deposited, and the supernatant oil becomes clear and of a dilute yellow colour: and when this oil is poured off into another vessel, a second deposition occurs, and then the oil obtained, being put into clear glass phials, may be kept for a considerable time, without undergoing any change. But if the oil be allowed to stand on the white matter, it becomes in a few weeks very rancid; nor can the common oil, even under proper management, be preserved in casks longer than a year and a half, or two years at the farthest. The specific gravity of olive-oil is .9153; it boils at about 500° Fahrenheit, and congeals at 36° or 38° Fahrenheit. The facility with which it freezes renders it improper for lamps, especially in cold countries; but by previously exposing it in an open clear glass phial to the sun-shine, it may be so far amended in this respect, as to continue fluid at 21° Fahrenheit. Olive-oil is often sophisticated by a mixture of poppy oil, which renders it drying, a quality which the genuine oil does not possess. In countries that produce it, it is used for food, as butter is with us: that of the inferior kinds is burnt in lamps, or employed in the manufacture of soaps, which are of a finer quality than those that are composed of animal oils. The best oil is made in Provence; but that which we receive in this country is brought from Lucca and Florence. It is imported in jars, half-jars, and half-chests, which are wooden packages containing flasks.

Olive-oil is used in medicine, internally, as a demulcent in catarrh and other pulmonary affections, diffused in water by means of mucilage; and it is also given, in large quantities, to mitigate the action of acrid substances, as some poisons, taken into the stomach; and in cases of worms, applied externally it is a very useful relaxant, and instead of stopping up the cutaneous exhalants, appears to promote the excretion of sweat, on which account it is beneficially employed in frictions at the commencement of the plague. The body is ordered to be very briskly rubbed all over with a clean sponge dipped in warm olive-oil, and the operation is repeated once a day until symptoms of recovery appear. Mr. Jackson relates, that the coolies, who are employed in the oil-stores at Tunis, smear themselves all over with oil, and are seldom afflicted with the plague when it rages in that city. Frictions with it are useful in ascites. It is also used as an injection in gonorrhœa; as an adjunct to glysters in dysentery and intestinal abrasions; and extensively in pharmacy, in the compositions of ointments and plasters.

The dose of olive oil is from f.℥ss to f.℥j, triturated with mucilage, or mixed with water by means of a few drops of solution of potash. In cases of poisons and worms, as much may be given as the stomach can bear. The officinal preparations of oil, besides cerates and ointments, are Oleum sulphuratum, L. E. Linimentum ammoniæ fortius, L. E. D. Linim. ammoniæ carbonatis, L. Linim. calcis, D. Linim. camphoræ, L. E. D. Emplastrum plumbi, L. E. D. Emp. hydrargyri, E. Emp. oxidi rubri ferri, E. Enema catharticum, D.

For the "oleum sulphuratum," see preparations of SULPHUR. For the liniments, see LINIMENT. For the plasters, see EMPLASTRUM and PLASTER. Aikin. Thomson.

OIL *of Orange-peel.* See AURANTII *Cortex.*

OIL *of Origanum.* See MARJORAM.

OIL, *Palm,* or *Oil of Senegal,* a thick unctuous liquor, of a yellow colour, and a violet smell; so called, because drawn, by ebullition, or by expression, from the fruit of a kind of palm-tree, growing in several places of Africa, especially in Senegal.

Many of the palms produce nuts, which abound in oil. The principal of these are the Cocos *Butyracea,* and ELAIS *guineensis.* The ripe fruit is collected in a heap, and slightly fermented; it is then coarsely pounded and macerated in hot water, and thus its oil is parted with and swims on the surface of the water, which by cooling concretes into a solid cake. It is purified by washing in hot water, and thus becomes fit for use. It has a light brown-yellow colour, little or no taste, but a high odour and flavour like those of the Florentine iris; by long keeping it becomes rancid, and is then nearly white, and almost without odour.

The Africans and the Negroes in the West Indies use this oil as we do butter; and burn it in their lamps when old. With us, it is only used in some external applications, for pains and weakness of the nerves, cramps, sprains, and other such complaints. The common people sometimes apply it to chilblains; and when used early, not without benefit. It is also employed in the composition of the best yellow soap. It is sometimes counterfeited with wax, oil of olives, iris, and turmeric; but the trick is found out either by air or fire. The air alters the colour of the genuine, and leaves the counterfeit unchanged; and, on the contrary, fire changes the counterfeit, but does not alter the genuine.

OIL *of Penny-royal.* (See MENTHA *Pulegium.*) This oil, which is of a reddish-yellow colour, resembles in its other qualities the oil of pepper-mint. Its specific gravity is .978. It is stimulant and antispasmodic, but seldom used. The dose may be from ♏j to ♏v, given on a lump of sugar.

OIL *of Jamaica Pepper.* (See PIMENTO.) This oil has the agreeable odour of the pimento, with its pungent taste augmented. Its colour is reddish-brown, and it is heavier than water. It has the same properties with the all-spice, but in a greater degree: it is given in dyspeptic affections, colic, and tympanitis, in doses of from ♏iij to ♏v, rubbed with sugar, or in any proper vehicle. Its officinal preparation is emplastrum aromaticum of the Dublin college. See PLASTER.

OIL *of Pepper-mint.* (See MENTHA.) This is a common domestic remedy in cramp of the stomach, flatulent colic, and anorexia; and usually rubbed up with sugar or mucilage. The dose is from ♏j to ♏iij. The officinal preparations are pilulæ thei camp. E. Pilulæ aloes cum zingibere, D.

OIL *of Petrol.* See NAPHTHA and PETROLEUM.

OIL *of Pimento.* See PIMENTO, and OIL *of Jamaica pepper, supra.*

OIL *of Black Pitch.* See PITCH.

OIL *of Poppy-seed,* or *Pink-oil,* is extracted by cold-drawing from the seeds of the large white poppy (*Papaver somniferum*), which is largely cultivated for this purpose in France, the Netherlands, and various parts of Germany. It is transparent and nearly colourless, and when well prepared, has no other taste or flavour, than a slight one of nut-kernels. Its specific gravity is .9288. This is one of the naturally drying oils, and like all of that class is frozen with difficulty; it may be cooled down to 0° of Fahr. without congealing. When employed as food, it is scarcely to be distinguished from olive-oil, which is often adulterated with it. The quantity of oil yielded by a given weight of the seeds depends partly on the country and season in which the seeds are produced, and partly on the mode of extracting the oil. From 100lbs. of fresh seeds, some state the produce of oil at 25lbs., and others at 58lbs. It is used as an article of diet, and in the composition of varnishes, but it is very unfit for burning in a lamp. See PAPAVER and POPPY.

OIL *of Rape-seed.* See RAPE, and OIL *of Cole-seed.*

OIL, *Red,* in the *Porcelain Manufacture,* a name given to

a peculiar colour uſed on the china-ware, or to thoſe pieces of the ware which are coloured with it. It is a very elegant ornament, and would be worthy our attempting to imitate in England, on our better ſorts of wares. They do it in the following manner: they mix the red colour, called *tam-lan-hum*, or the copperas red (ſee PORCELAIN) with *oil of ſtone*, and with another oil, as they expreſs it, of the ſame kind, made of a whitiſh ſort of pebble, or agate, found on the ſhores of their rivers, and the place of which might probably be ſupplied with us by common cryſtal. The powder is to be thoroughly mixed with theſe liquors, and the veſſel dipt carefully into the mixture, or ſome parts of it only covered with it in figures: after this, it is to be ſet by to dry, and, when thoroughly dried, it is to be baked in the common way. The general method is that of covering the veſſel all over, both inſide and out, with this red; and it comes out of the moſt bright and brilliant colour imaginable, but it will not ring when ſtruck upon, as our common china-ware does. We ſeldom ſee this in any degree of perfection, but it is very elegant when fine.

OIL, *Rock*. See PETROLEUM.

OIL *of Roſemary*. (See ROSEMARY.) Twenty-four pounds of the plant yield one ounce of a fluid colourleſs oil, the odour of which is leſs agreeable than that of the plant. It depoſits cryſtals of camphor when long kept. Its ſpecific gravity is .934. As to its medical properties, it is ſtimulant, and frequently enters into the compoſition of liniments. The doſe, as an internal remedy, may be from ♏ ij to ♏ vj; but it is ſcarcely ever ordered. The officinal preparations are tinctura ſaponis, and alcohol ammoniacum aromaticum.

OIL *of Rue*. (See RUTA.) Twenty-one pounds of rue yield 59 grains of oil, which has the ſtrong ungrateful odour and taſte of the plant. When recently drawn the colour is yellow, but it deepens into brown by age, and depoſits a browniſh reſinous ſediment. It congeals at 40° Fahr. Oil of rue is ſtimulant and antiſpaſmodic; it is ſometimes given in hyſteria, and the convulſive affections of children attendant on dentition; and is alſo occaſionally uſed as a rubefacient in palſy. The doſe is from ♏ ij to ♏ v, triturated with ſugar or mucilage.

OIL *of Sage*. See SAGE.

OIL *of Saſſafras*. (See SASSAFRAS.) Sixty pounds of ſaſſafras yield 12 ounces of a viſcid yellow oil, heavier than water; its ſpecific gravity being 1.094. Its odour is fragrant, and its taſte hot and acrid, excoriating the lips when incautiouſly taſted.

The oil of ſaſſafras is peculiarly liable to cryſtallization in certain circumſtances, and that into the moſt beautiful forms. Mr. Maud gives an account of a quantity of this oil, which having ſtood expoſed to the air in a very froſty night, in an open veſſel, was in the morning found changed three parts in four of it into very beautiful and large cryſtals: they were of an hexagonal form, very tranſparent, and of three or four inches in length, and half an inch in thickneſs. Theſe cryſtals ſubſided in water, and were indiſſoluble in it; they were readily inflammable at the fire, and were reduced by heat to their priſtine fluid ſtate: hence it is evident that they ſtill retain the natural qualities of an oil, though they appear under ſo very different a modification of their parts. What is moſt remarkable in this change, is, the metamorphoſis of a fluid to a ſolid body, of ſo determinate and regular a figure, and that theſe cryſtals ſhould be perfectly clear and colourleſs, though the liquor from which they froze was of a yellowiſh colour, not unlike that of Madeira wine.

This oil is ſtimulant, and ſuppoſed to be alſo ſudorific and diuretic. It has been given in chronic rheumatiſm, ſcurvy, and ſome cutaneous affections. The doſe is from ♏ ij to ♏ x; but it is ſcarcely ever ordered.

OIL *of Savine*. (See JUNIPERUS.) Two pounds of ſavine are ſaid to yield five ounces of oil, which is limpid, of a pale yellow colour, having the odour of the plant, and being very acrid to the taſte. This oil is the principle on which the virtues of ſavine depend; hence it poſſeſſes the ſame properties, and is applicable to the ſame purpoſes as the plant. The doſe may be from ♏ ij to ♏ vj, triturated with ſugar.

OIL *of Spearmint*. (See MENTHA.) The flavour of this oil is ſimilar to that of pepper-mint, but leſs grateful; its taſte is warm, and leſs pungent; its ſpecific gravity is .975, and its colour greeniſh. Its medical properties are the ſame with thoſe of oil of peppermint. The doſe is from ♏ ij to ♏ v, given on a lump of ſugar. Its officinal preparation is infuſum menthæ compoſitum, which is prepared, according to the directions of the Dublin college, by taking of the leaves of ſpearmint, dried, two drachms, and a ſufficient quantity of boiling water to afford ſix ounces by meaſure when ſtrained; digeſting for half an hour, but ſtraining the liquor when cold, then adding of refined ſugar two drachms, oil of ſpearmint, three drops diſſolved in half an ounce (fluid?) of compound tincture of cardamoms; and mixing the ingredients. This is a grateful ſtomachic, and is ſlightly diaphoretic. It may be ſerviceable in anorexia and nauſea, and as a vehicle to cover the diſagreeable taſte of other medicines. The doſe may be from f. ℥j to f. ℥iij, or at pleaſure.

OIL, *Stillatitious*. See STILLATITIOUS.

OIL *of Stone*. In the manufacture of the Chineſe porcelain, they uſe a liquid matter of a white colour, which they call by this name, on which their great myſtery of finiſhing their work depends; yet this has been leſs enquired into by the imitators of that ware in Europe than many other articles of leſs conſequence. The ſtone of which this oil is made, is of the ſame degree of hardneſs with that which the petunſe is prepared of. They procure it from quarries, and chooſe ſuch as is of a good white colour, and has many dark green ſpots in it.

Theſe ſpots are of the colour of the leaves of cypreſs. Sometimes a ſtone is choſen which has a brown ground, variegated with ſpots and blotches of a reddiſh colour. They firſt carefully waſh this ſtone; then laying it in a clean place, they break it to pieces with iron inſtruments, and afterwards grind theſe to a perfectly fine and impalpable powder, by rubbing them in large mortars, with peſtles of ſtone faced with iron, and turned either by the labourers, or by water. When the whole is thus reduced to a fine powder, they throw it into a veſſel of water; and ſtirring it briſkly about, they let the coarſer part ſubſide to the bottom, and there ſwims a fine thick matter like cream, for two or three inches depth on the ſurface. This they carefully ſkim off, and putting it into another veſſel, of clear water, they let it throw down any coarſe matter it may yet contain; and, finally, taking off the thick ſurface again, they mix this with ſome freſh water in another veſſel, and leave it to ſubſide; then pouring on the clean water, they take out the remainder at the bottom of the veſſel, which is perfectly fine, and reſembles a thick cream. To every hundred pounds of this they add one pound of a ſubſtance of the nature of which we are not yet perfectly informed. It is ſaid to be a mineral reſembling alum. They calcine this firſt, and then beat it to a fine powder; and this being added to the cream, or oil, as it is called, ſerves to keep it always in the ſame liquid ſtate. This ſubſtance, when finiſhed in this manner, has very little title to the name of an oil; it is rather a varniſh, and is always uſed in mixture with another varniſh, which

is called at this time fern oil, and ufed to be called lime oil; it is prepared in the fame manner with the other after burning. See FERN-*Oil*.

OIL *of Sulphur* is a name given to the concentrated acid of fulphur. See OIL, *fupra*, and SULPHUR.

OIL *of Tartar*. See TARTAR.

OIL, *Train*. See *Whale* FISHERY, TRAIN, and WHALE.

OIL *of Turpentine* is obtained by diftilling the refin with water in a common ftill, when the oil is found in the receiver fwimming on the water, from which it is eafily feparated. The average proportion is 60lbs. of oil from 250lbs. of good turpentine. This procefs is carried on both abroad and at home; but the oil drawn in this country is always preferred. (See PINUS, and TURPENTINE.) The Dublin college directs 5lbs. of turpentine and four pints of water, and the oil to be diftilled from a copper alembic. Yellow refin will remain in the retort after the diftillation.

The *rectified* oil of turpentine of the London and Dublin college is obtained from a pint (two pints Dub.) of oil of turpentine, and four pints of water. Diftil the oil (a pint and a half of the oil, Dub.)

Purified oil of turpentine of the Edinburgh college is obtained from 1lb. of oil of turpentine, and 4lbs. of water; and diftilling as long as any oil paffes over. The rectification of the oil is a troublefome procefs, and on account of the great inflammability of the vapours, much caution is required to prevent them from efcaping through the lutings of the veffels, and catching fire. The rectified oil is a little lighter than the common oil, and completely free from any refinous admixture; but in other refpects it has no peculiar excellence to recommend it. What remains in the retort is a thick refinous matter, and is denominated "balfam of turpentine." (See BALSAM.) For the chemical and medicinal properties of oil of turpentine, fee PINUS, TURPENTINE, and TAPE *Worms*.

OIL *of Venus*, a name given by Lemery to the falt formed by the union of copper with the nitrous acid, when it is refolved into a liquor by the moifture of the air. This is a cauftic and efcharotic.

OIL, *Virgin*, is underftood of oils expreffed from olives, nuts, &c. frefh gathered, without being heated, too much preffed, &c. See OIL *of Olives*.

OIL *of Vitriol*. See SULPHURIC *Acid* and VITRIOL.

OILS, *Volatile*. (See OIL, *fupra*.) For the method of preparing thefe oils by the London college, fee *Diftilled* OILS, and for thofe of the Dublin college, fee *Effential* OILS, *fupra*. The Edinburgh college directs the volatile oils to be prepared in the fame manner as the diftilled waters, except that lefs water is to be added. Seeds and woody fubftances muft be previoufly bruifed or rafped. The oil diftils over with the water, and, as it is lighter or heavier, floats on the furface or finks to the bottom, and is afterwards feparated. It is neceffary to obferve, in preparing thefe oils, and alfo the diftilled waters, that the quality of the fubftances, their texture, the feafon of the year, and fimilar circumftances, muft occafion fo many differences, that no general rules, that are applicable to every cafe, can be laid down. Few of the volatile oils are prepared by the apothecary. The oils of anife, chamomile, juniper, origanum, rofemary, and pimento, are ufually imported into this country; while thofe of lavender, peppermint, fpearmint, and penny-royal, are annually prepared on a large fcale.

As medical agents, volatile oils are ftimulant and ftomachic. They are chiefly employed to remove naufea and flatulence, to correct the griping qualities of fome purgatives, and the difagreeable tafte of other remedies. They may be given triturated with water and mucilage; or dropped firft on a lump of fugar, and through its medium diffufed in water, forming a folution of what has been denominated "oleum faccharinum." The quantity of fugar muft be more than ten times the weight of the oil; and when they are well triturated together the oil becomes thus completely foluble in water, and may be diluted to any extent. Some of the more ftimulant of thefe oils are added to embrocations to be ufed as rubefacients in cafes of numbnefs, pains, and paralytic affections of the joints. Thomfon.

OIL *of Wax*. See WAX.

OIL frequently takes new names from the drugs mixed with it; as *oil of rofes*, which is that mixed with rofes; *oil of jeffamy*, that perfumed with jafmin.

OIL *of Wine*. See ETHER.

OIL, *Anointing with*. See UNCTION.

OIL-*Bag*, a veffel in birds replete with an unctuous fubftance, fecreted by one fometimes two glands, for the purpofe, difpofed among the feathers; which being preffed by the bill or head, emits its oily matter for dreffing and pruning the feathers. See *Anatomy of* BIRDS.

OIL *Beetle*. See *Oil* BEETLE.

OIL-*Bladders*, in *Vegetable Phyfiology*. See *Secretions of* VEGETABLES.

OIL-*Dregs*. See DREGS.

OIL, *Gilding in*. See GILDING.

OIL, *Painting in*. See PAINTING.

OIL *Mill*, in *Mechanics*, is a machine ufed to exprefs oil from linfeed, rape-feed, and other oleaginous grain, but chiefly from the above-mentioned for the ufe of painters. Olive and other vegetable oils, the produce of the fouth of Europe, are alfo expreffed by a machine, but it is not called a mill, being fimply a ftrong fcrew-prefs, provided with a windlafs or capftan, to give it a greater power; in fhort, it is the fame machine as the CYDER *Prefs* (fee that article). The olives are firft pounded, or bruifed, either in a large mortar, or by a running ftone, in the fame manner as the apples for making cyder. The pulp thus produced is put up in bags made of horfe-hair, and a pile of thefe, being made up under the prefs, the fcrew is forced down by men working at a long lever, and the oil expreffed: it runs very freely at firft, and this, which is efteemed the beft quality, is in fome countries kept feparate. When this preffure has continued an hour or two, the power of the capftan is applied. This produces a good quantity of oil of the fecond quality, which is fold at an inferior price; and in fome provinces of Spain, where the olive is extenfively cultivated, it is ufed to burn in their lamps.

The oil-mill we intend to defcribe in this article is for a different purpofe; *viz*. the expreffing of linfeed and rape-feed oils. Thefe grains are exceedingly hard and fmooth on their furfaces, and the fragments of their fhells, however broken, form little concavities which will retain the oil, unlefs a far greater preffure is applied than can be obtained by a fcrew-prefs; it is, therefore, done by a wedge-prefs. This confifts of a ftrong block of wood, or a caft iron frame, in which a long mortife is made: in this a bag of bruifed feed is placed at each end, and blocks being put in to fill up the mortife, a wooden wedge is introduced between the blocks, and driven in by repeated blows of a heavy ftamper, which is raifed up by the power of the mill, and let fall upon the wedge, till it has driven it down as far as it will go. This caufes a moft immenfe preffure upon the feed contained in the bags, and forces out the oil at every blow of the ftamper: for it is a curious fact that the fame

preſſure, gradually produced, will not expreſs any ſenſible quantity of oil; it muſt, therefore, be done by a ſudden and violent acceſſion of force; accordingly, at every ſtroke upon the wedge, the oil exudes in conſiderable quantity from the ſeed, until the whole is expreſſed, leaving a cake of ſeed as hard as a piece of board. Theſe oil-cakes are very good food for cattle.

The machinery of an oil-mill is explained by the drawing in *Plate Oil-mill*, where *fig.* 1. is a plan, and *fig.* 2. an elevation, of a very good mill of this kind, which was erected after the deſigns of the late John Smeaton, eſq. F.R.S.; whoſe proportions for the parts of mills have been ſcarcely improved ſince his time; though in the conſtruction of the wheels, &c. caſt iron has of late years been ſubſtituted for wood almoſt univerſally. A, in both figures, is the water-wheel actuating the whole mill; it is underſhot; that is, the water paſſes under it, and turns the wheel, by its momentum ſtriking upon the floats (See WATER-WHEEL.) It works very cloſe, in a pit formed between the two walls *c*, C, the latter being the outſide wall of the mill-houſe: it is framed on a ſtrong octagonal ſhaft B B, turning on two gudgeons fixed in its ends: D is the pit-wheel, or great cog-wheel, fixed upon the main ſhaft, within the houſe: it has wooden teeth fixed in its rim, parallel to its axis, in the manner of a crown-wheel. There are 80 of theſe teeth, by which it turns a ſmaller wheel, E, of 37 teeth, fixed on an horizontal ſhaft, F, called the tumbling ſhaft, extending nearly acroſs the houſe It gives motion to the ſtampers, V, W, of the preſs, and alſo the rolling ſtones or runners, I, K, which bruiſe the ſeed. The latter is done by means of a wheel, G, with 35 teeth, fixed on the end of it, for the purpoſe of turning a large wheel, H, of 72 teeth, which is fixed upon a vertical ſhaft, *n*, which gives motion to the running ſtones, I, K. Theſe are two circular ſtones, fitted upon an iron axle, the ends of which are ſhewn at *a a*. This axle paſſes through the vertical ſhaft *m*, and alſo through runners: thus they have two motions, a rotation round their own axis, by which they are carried round upon the nether or horizontal mill-ſtone, L, on which they roll The centre-holes in theſe running mill-ſtones are made a little wide, and the hole in the ſhaft *m*, which carries the middle of the iron axis, is made oval up and down. This great freedom of motion is neceſſary for the runner mill-ſtones, becauſe frequently more or leſs of the grain is below them at a time, and they muſt therefore be at liberty to get over it without ſtraining the ſhaft.

The lower mill-ſtone, L, is ſupported on maſonry, and ſurrounded by a border or ledge of wood *d d*, which prevents the ſeed being ſcattered: the two ſtones I, K. as the figure ſhews, are placed at different diſtances from the central axis *m*, ſo that they run in different paths, and thus bruiſe the ſeed more effectually than if they followed each other in the ſame circuit: *n*, *n*. are the ends of two wooden rails, projecting from the ſhaft *m*, and at their ends ſupporting two upright pieces of wood, which, at their inferior extremities, carry ſweeps or rakes: theſe drag round upon the ſurface of the lower ſtone, and turn the ſeed about, to receive the greateſt poſſible action from the ſtones I, K, rolling over it. There are two of theſe ſweeps on the oppoſite ſides of the ſtones, one called the outer rake, and the other the inner rake. The outer rake collects the grain under the runner from the ſurface of the border *d*. In this manner the grain is turned over and over, and cruſhed in every direction. The inner rake lays the grain in a ſlope or ridge, over which the runners paſs, and cruſh it: then the ſecond rake lifts it again into a ridge, to receive the action of the next ſtone, ſo that every ſide of the grain is preſented to the runner mill-ſtone, and receives its action, while the reſt of the lower ſtone is ſwept by them ſo clean, that not a ſingle grain is left on any part of it. The outer rake is alſo furniſhed with a rag of cloth, which rubs againſt the border of a hoop which ſurrounds the nether mill-ſtone, ſo as to drag out the few grains which might otherwiſe remain in the corners. There is alſo another ſweep, making part of the inner rake, which is occaſionally let down for ſweeping off all the ſeed when it has been ſufficiently bruiſed. The preſſure and action of theſe rakes are adjuſted by means of wooden ſprings, which cannot be eaſily and diſtinctly repreſented by any figure. The oblique poſition of the rakes (the outer point going foremoſt) cauſes them to ſhove the grain inwards, or towards the centre, and at the ſame time to turn it over ſomewhat in the ſame manner as the mould board of a plough ſhoves the earth to one ſide, and partly turns it over. Some mills have but one ſweeper, and indeed there is great variety in the form and conſtruction of this part of the machinery. The great pit, D, turns a ſmall cog-wheel *e*, *fig.* 1, on whoſe ſpindle is fixed one of the two iron rollers *f*, *g*, which are uſed for bruiſing the ſeed, as in the firſt operation.

Theſe rollers are made of caſt iron, and truly turned in a lathe, their ſpindles turning in braſs buſhes, fixed in iron frames bolted down to the wood work. Theſe frames have mortiſes in them, in which the buſhes for the pivots of the roller, *g*, are placed, with liberty to ſlide in the mortiſes when they are puſhed up by ſcrews ſcrewed through the ends of the iron frames. By theſe means the rollers can be ſet at any diſtance apart, according to the ſize of the ſeed which is to be cruſhed between them; *l*, *l*, are two ſmall iron cog-wheels, of 15 teeth each, fitted on the ends of the pivots of the rollers; they make both rollers turn together with the ſame motion: the ſeed is put into a hopper, ſupported at ſome diſtance above the roller, and it runs out at an opening in the bottom into a trough called the ſhoe, which is continually ſhaken by means of a piece of wood nailed to it, and reſting upon the cog-wheel *l*. By this means the ſhoe continually feeds the rollers with a ſmall quantity of ſeed, without any danger of choaking them up, and the ſeeds fall, from the end of the ſhoe, between the rollers, which, as they turn round, take the ſeed in between them, and bruiſe it. It is proper to have a piece of iron plate nailed to ſome part of the frame, and kept conſtantly preſſing againſt the rollers, ſo as to ſcrape off the ſeed which may adhere to them. The ſeed, after having paſſed between the rollers, falls upon an inclined board, placed in the frame beneath them, and is thus ſhot down in a heap before the rollers, from whence it is conveyed by a labourer to the rolling ſtones.

The preſs comes next to be noticed, for we have hitherto only deſcribed the machinery for bruiſing the ſeed previous to expreſſing the oil from it.

The tumbling ſhaft, F, has two lifters, M, N, projecting from it, which as it turns round lifts up and lets fall the ſtampers, V, W, of the preſs. They riſe and fall in a frame conſiſting of two thick pieces of wood P, P, firmly bolted together at the bottom by beams T, T, extended between them. The ſpace between theſe beams is filled up by the bags of ſeed at *d*, *d*, *fig.* 2, the preſſing wedge *b*, the diſcharging wedge *c*, and blocks of wood, to keep them at the proper diſtance apart.

The beams, T, T, have croſs pieces upon them, between which the ſtampers, V, W, ſlide up and down: they are lifted up by the wipers or lifters M, N, fixed upon the ſhaft F: theſe take hold of tappets or chocks projecting from the ſtampers, and raiſing them to the proper height, let them fall on the wedges. When they are to be ſtopped, the workman pulls a rope, which raiſes a lever, and holds up the ſtamper too high to meet the lifter in its revolution. The

inverted wedge, *c*, is fuspended by a rope from a wooden fpring, which raifes it up, as in the figure, when the other wedge is taken out for the purpofe of putting a frefh charge of feed in the bags at *d d*. The opening of the prefs, or the fpace contained between the uprights, P, P, of the frame, and the two beams T, T, has a very ftrong caft iron frame within it, which refifts the preffure to rend the prefs open. The upper edge of this frame is fhewn by the dark line in *fig.* 2, and the internal parts are fhewn by dotted lines.

The bags of feed, *d*, *d*, are included between two iron plates, united together at the bottom in the manner of book lids, and the bag is fhut up between them: immediately beneath thefe are fmall holes in the bottom of the prefs, at which the oil oozes out into fmall pots *k*, *k*: the blocks which fill up the prefs reft upon the bottom of the prefs, to prevent them being carried down by the action of the wedges which flide againft them, having thin pieces of wood between, to make them flide eafily by each other: the preffing wedge, *b*, has its point downwards, and is driven by the ftamper V: the difcharging wedge *c* is inverted, its fmalleft end being upwards; and this, when ftruck by the ftamper W, is forced down, and thus releafes the prefs, when it would be exceedly difficult to difengage it by any other means, the preffing wedge being driven in very faft by the repeated blows of the ftamper V.

There is likewife a fmall apparatus in an oil-mill called the fire gear or chaufer pan, which we have omitted in our plate. It is intended to keep the bruifed feed ftirring whilft it is heated in a copper pan, previous to preffing, as this is found to increafe the produce of oil. The chaufer pan confifts of a fmall fire-place, fituated in the corner of the mill-houfe, and heated by burning charcoal in it. The feed is contained in a circular copper pan, which is fet over the fire, and the feed is prevented from burning to the bottom of the pan, by a crofs piece of iron fixed to the lower end of a vertical fpindle, which, as it turns round in the pan, ftirs the feed. The fides of this crofs are fet inclined, fo as to fcrape the feed from the bottom of the pan, and throw it over the back of the ftirrer. The fpindle for the ftirrer is put in motion by means of a train of fmall wheelwork, receiving motion from a rigger or pulley fixed upon the tumbling fhaft F, by means of an endlefs chain or rope. In many of the moft improved mills the chaufer pan is heated by fteam inftead of charcoal: in this cafe it has a falfe bottom on which the feed lays, and the fteam from a boiler is admitted into the fpace beneath the bottom. This is found to give the proper heat with greater precifion than can be done (except by experienced workmen) with the charcoal fire; for if the heat is too great it makes the oil rancid, and if it is too low the produce of oil will be diminifhed. In either cafe the pan muft have a fmall opening on one fide, and a fluice to fhut it up and keep in the feed until it is properly heated. Immediately beneath the door are two hoppers, which lead the feed down at the fide of the furnace, and conduct it into the flannel bags, which are hung at the lower extremity, or fmall openings of the hopper. When the feed is fufficiently heated, and the prefs is ready for it, the fluice is opened, and the ftirrer throws the feed out into the hoppers and the bags. Thefe are made of flannel cloth, which is found the beft fubftance to refift the preffure and admit the oil through. The bags, before they are put into the prefs, are flattened by the hand, and wrapped up in a long flip of very thick leather, which enclofes it, and prevents the bag being burft by the preffure.

Our readers will now comprehend the ftructure of the oil-mill; but as in all operations of this nature much management is requifite to carry them on to the beft effect, we fhall briefly defcribe the procefs followed by our moft careful manufacturers of oil.

Linfeed and rape-feed are the produce of almoft every county in England, and as the confumption of the oil for painting is not confined to particular places, the manufacture is carried on in every part of the kingdom. A great number of oil-mills are to be met with in Hull, and other parts of Yorkfhire, where they have the advantages of falls of water. The feed is firft bruifed between the rollers, to crack every grain without feparating their parts: this very much facilitates the operation of the grinding, for the grains are fo hard and fmooth, that they flip away from beneath the runner-ftones, and it would require a long time to get all the grains crufhed; but by the rollers every grain is broken, and then the runner-ftones act with proper effect. The rollers require fo much power, that in fmall mills they cannot drive the other machines at the fame time; but this is no objection to them, becaufe they act with fuch rapidity, as in a very fhort time to bruife feed enough for the whole day's work. The feed, after being crufhed between the rollers, is fpread by a fhovel upon the nether mill-ftone L, to be ground by the runners. That this may be more expeditioufly done, one of the runners is fet about two-thirds of its own thicknefs nearer the fhaft than the other. Thus they have different circuits, and the grain, which is a little heaped towards the centre, is thus bruifed by both. The inner rake gathers it up under the outer ftones into a ridge, over which the ftone paffes and flattens it: it is then gathered up again by the outer rake into a ridge under the inner ftone. The outer rake confifts of two parts; the outer part preffes clofe on the wooden border *d d*, which furrounds the nether ftone, and fhoves the feed obliquely inwards, while the inner part of this rake gathers up what had fpread towards the centre.

The outer rake has a joint near the middle of its length, by which the outer half of it can be raifed from the nether ftone, while the inner half continues preffing on it, and thus fcrapes off the moift feed, which is like a pafte. When the feed is fufficiently bruifed, the miller lets down the outer end of the rake; this immediately gathers the whole charge, and fhoves it obliquely outwards to the wooden rim, where it is at laft brought to a part that is left unboarded, and it falls to the ground. In the Dutch mills it falls through troughs placed to receive it. Thefe troughs have holes in the bottom, through which the oil drips all the time of the operation. This part of the oil is conveyed into a peculiar ciftern, being confidered as the pureft of the whole, having been obtained without preffure, by the mere breaking of the hull of the feed.

The feed in this country is feldom fo ripe as to yield any oil in this ftage without preffure; but in fome mills they take a quantity of their beft feed from the ftones, and putting it into bags give it a moderate preffure by a fcrew-prefs. The oil thus obtained is called cold drawn, and is fold at a higher price for the ufe of cabinet makers, who rub their ornamental wood work with it to give a polifh: in other work, the cold drawn oil is nothing more than the firft obtained by the prefs, but without heating the feed.

In fome of the Dutch mills, a much greater quantity of oil is obtained in the grinding, without preffure, by having the bed of mafonry, which fupports the lower mill-ftone, formed into a little furnace and gently heated. But the utmoft care is neceffary to prevent the heat from becoming confiderable. This enabling the oil to diffolve more of the fermentable fubftance of the feed, expofes the oil to the rifk of growing foon very rancid, and in general it is thought

a hazardous practice, and the oil does not bring so high a price.

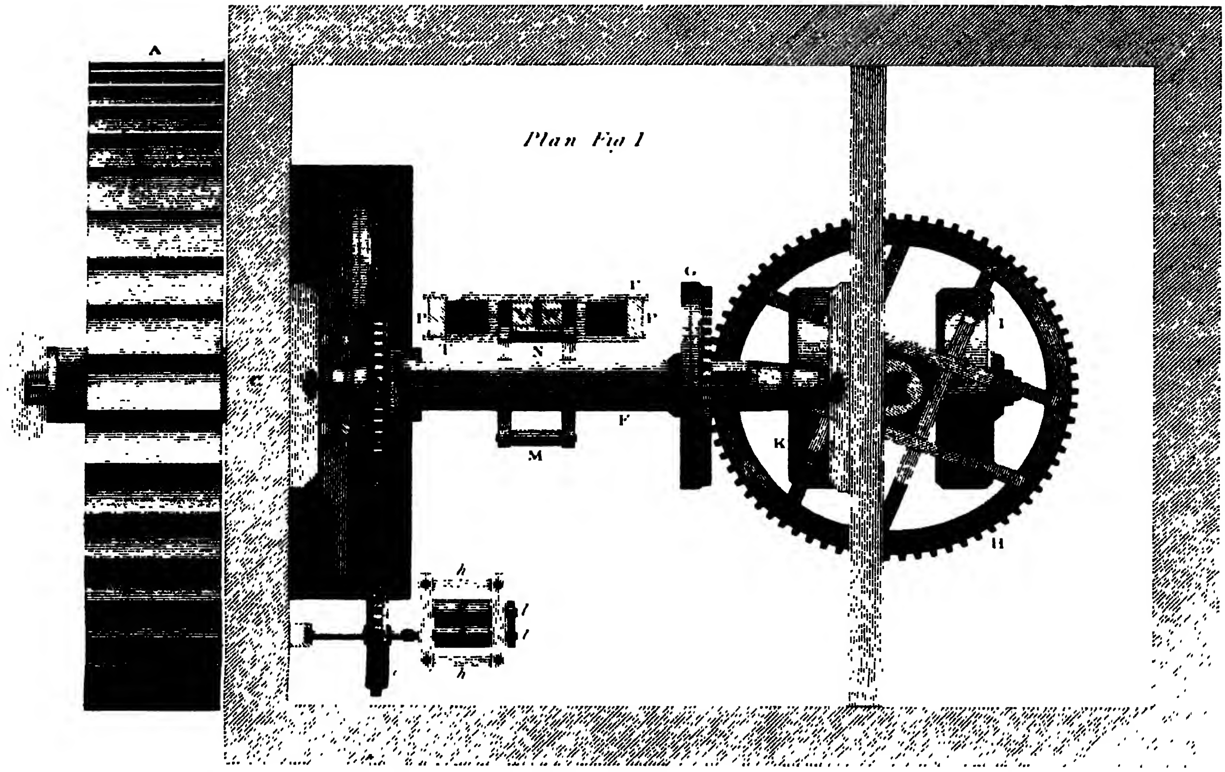
When the seed is very dry, a little water is thrown in among it whilst grinding, which is found to facilitate the process. In about twenty minutes a charge of seed will be sufficiently ground, and is then carried to the chaufer pan, where it is heated previous to being pressed. Here the stirrer keeps it from burning to the bottom of the pan: while this is doing the wedges of the press are taken out, both the stampers are hauled up, and the iron lids at *d d*, which are to include the bags of seed, are opened out ready to receive them. When the seed is sufficiently heated the sluice is opened, and the stirrer throws it out into the bags, the workman flattens them, wraps them in the leather, and puts them into their places. The wedge, *b*, is now introduced, and the stamper, V, disengaged to drive it down. After a few blows the oil begins to run, and this continues till the wedge gets so fast, that the stamper will rebound up from it two or three times: it is then judged that it can be driven no farther. The stamper, V, is now hauled up, and the other let loose. This at one or two blows drives down the wedge W, and relieves the pressure, after which the wedge and the bags may be taken out to put in a fresh charge. The contents of the bag are compressed into a dense cake, from which the bag is stripped off, and the cakes are ground up, and subjected to a second pressure. They are broken into pieces by the shovel, and thrown under the runners, where the cake is again broken down, and the parenchyma of the seed reduced to a fine meal. Thus free egress is allowed to the oil from every vesicle in which it is contained. But it is now rendered much more clammy by the forcible mixture of the mucilage, and even of the finer parts of the meal. When sufficiently ground the workman conveys the paste to the chaufer pan, where it is heated rather more than for the first time, and the second pressure is conducted in the same manner as the first. The produce of oil from the second operation is very uncertain; as it depends upon a number of circumstances. It will sometimes exceed the quantity of the first time, and at other times it will not be half as much. The bags for the second pressure are filled with twice as much seed as the first time, and the cake will be more than twice as thick. The linseed cakes are sold at a high price for cattle, but the rape-seed cakes are ground to a coarse powder, and in that state sold for manure.

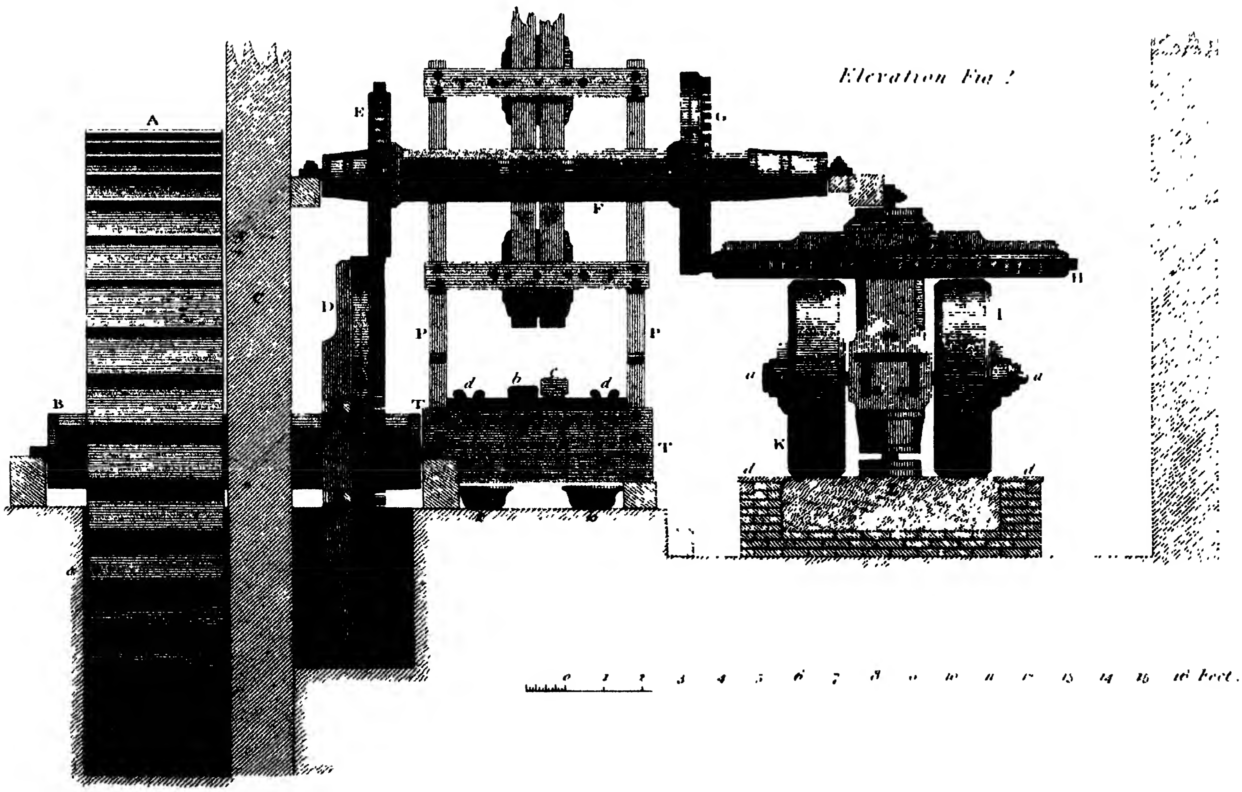
The mill shewn in our plate is on a small scale, but many mills have from 10 to 15 presses in use. A press will generally press seven cwt. of seed *per* day the first time, but only two, or two and a half cwt. for the second time, because it requires as much more time for the last operation.

Respecting the produce of oil from linseed, we have found from an average of four months work of an oil-mill in Yorkshire, that 280 quarters of linseed, generally weighing 30 stone (of 14lbs. each) *per* quarter, produced 5616 gallons of oil, which is at the rate of $20\frac{2}{35}$ gallons *per* quarter. The greatest produce in the period from which this average was obtained, was 409 gallons from 20 quarters, or $20\frac{9}{20}$ gallons *per* quarter. The least produce was $19\frac{4}{7}$ gallons *per* quarter.

OIL MILL

BY Mr SMEATON.





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Ores

Ores, in *Mineralogy* and *Metallurgy*, signify those mineral substances found in the earth, from which metals are procured. The ores of most of the metals consist of the metal combined with some other substance, and the process by which the metal is separated from the combined matter, is termed the reduction of the ore. We shall not here enumerate the ores of the different metals, as they are amply treated of under the respective metals.

Assay and Analysis.—This branch of operative chemistry is divided into two parts, the one called the humid, and the other the dry analysis. By the first of these, the substance is dissolved in acids or alkalies, and the different constituents separated by different re-agents. The dry process consists in first exposing the ore to a red heat, for the purpose of separating its volatile parts. The remainder is then treated with certain fluxes and inflammable matter, to separate the metal which is found in a rounded form, at the bottom of the crucible, and hence is called a button.

A little reflection will make it clear, that the humid analysis should always precede that of the dry. In order to know the nature of the particular flux to be employed after its ore has been roasted and its volatile products ascertained, it may be subjected to the action of some acid, and first the muriatic. If this has no action upon it, try the nitric; should this acid not dissolve the whole, try the nitro-muriatic, which may consist of equal parts of the two acids. If the whole is not dissolved by this, it may be presumed that the ore contains flint, or some salt not decomposable by the above acids. Under either of these circumstances it is proper to fuse the ore with pure potash, in a silver crucible. The fused mass will be of a dark green if iron be present, of a grass green if the ore contain copper, blue with cobalt, yellow with lead, and purple with manganese. This mass being boiled for some time with distilled water, till all the soluble matter is taken up, must now be treated with nitric acid. It is probable that all, except the silex, will be dissolved in the acid. From this acid solution, with the different lists, it must be ascertained what are the constituents of the ore, and afterwards the different substances must be separated with a view to determine their proportions. See under the different metals *Assay and Analysis.*

When the nature and proportions of the different substances combined with the metal constituting the ore are made out, the next thing is to expose it in a crucible, with such substances as will combine with the matter to be separated, the compounds either becoming fusible or being separated in the form of gas. For instance, in the smelting of iron ores of the argillaceous kind, lime is used in order to form a fusible compound with the alumine, and charcoal or coak in order to form carbonic acid with the oxygen of the oxyd of iron. If the ore contain silex, potash or soda should be used in order to form glass, which is greatly more fusible than the earth would have been with the metallic oxyd alone. Borax is frequently employed as a flux from its great facility of combining with the silex and other earths. See Stones, *Analysis of.*

Ores, *Dressing*, or *Washing of*, is the preparing them as they come rough from the mine, for the working by fire. This is done several ways in different countries, and in respect to the different ores of the metals. In Devonshire we have a very easy method, which is so expeditious, and so good for all the purposes, that it is worthy of imitation in other places. After the ore is dug, it is tossed up by hand from shamble to shamble by the shovel-men in the mine, and drawn up in buckets by a winch at the top of the shaft. As soon as the whole quantity for one dressing is brought up, the large stones are broken, and the whole is then carried to the mills, where one horse turns a wheel that moves the machines for powdering a great quantity of it: these are called the stamping or knocking mills. The ore is unloaded at the head of the pass or entrance into these mills: this pass is made of two or three bottom-boards and two side-boards, in form of a hollow trough, and stands in a slanting direction. The ore by its own weight is carried down this trough, and lodges itself in the coffer. The coffer is a long square box, made of the firmest timber, and of three feet long, and a foot and half broad. The ore is not suffered to fall into this all at once, but is stopped over the mouth of the trough by a cross board, where a cock turns in a quantity of water at the same time, which washes down just as much of the ore with it into the trough, as there ought to be. In this coffer there are three lifters placed between two strong board-leaves, having two braces or thwart-pieces on each side to keep them steady, as a frame with stamp-heads. These heads are of iron, and weigh about thirty or forty pounds a-piece, and serve to the breaking of the lumps of ore in the coffer.

The lifters are about eight feet long, and half a foot square. They are always made of heart of oak, and have as many in-timbers or guiders between them: they are lifted up in order, by a double number of tappets, which are fastened to as many arms passing diametrically through the great beam, which is either turned by the wheel and horse, or, where there is a conveniency of water, by an overshot water-wheel on two boulsters. The tappets exactly but easily meet with the tongues, which are so placed in the lifters, as that they easily slide from each other, and suffer the lifters to fall with great force on the ore in the trough. The frequent pounding of these soon reduces the large masses into a sort of sand, which is washed out of the trough by the continual current of the water from the cock through a brass-grate, which is placed at one end of the coffer between two iron bars. This operation is called by the miners *bricking*, or brick-working the ore. See Buddle.

The powdered ore is conveyed out of the trough into the *launder*, which is a trench cut in the floor of eight feet long, and ten feet over. This is stopped at the lower end with turf, so that the water is all suffered to pass away, and the powder of the ore is stopped. Thus the launder by degrees fills up with the dressed ore, and this is removed out with shovels, as occasion requires. The launder is divided into three parts, the forehead, the middle, and the tail: that ore which lies in the forehead, that is, within a foot and a half of the grate, is always the richest and best, and is laid up in a heap by itself; the middle and tail afford a poorer one, and these are sometimes laid up in separate heaps; sometimes thrown in one heap together.

Paper

PAPER, a thin flexible leaf, ufually white, artificially prepared of fome vegetable fubftance, chiefly to write upon with ink

The word is formed from the Greek παπυρος, *papyrus*, the name of an Egyptian plant, called alfo βιβλος, *biblus*, on which the ancients ufed to write.

Various are the materials on which mankind, in different ages and countries, have contrived to write their fentiments; as on ftones, bricks, the leaves of herbs and trees, and their rinds or barks; alfo on tables of wood, wax, and ivory; to which may be added plates of lead, linen rolls, &c. At length the Egyptian papyrus was invented; then parchment, then cotton paper; and, laftly, the common, or linen paper Vide Maffei Iftor. Diplom. lib. ii. § 3. 10. Bibl. Ital. tom. ii p. 242. Leo Allat. Antiq. Hetrufc. p. 127, feq. Hug de Scrib. Origin. Alex. ab Alexand. lib. ii. cap. 30. Barthol. diff. 4. de Libr. Legend. p. 90, feq.

In fome places and ages they have even written on the fkins of fifhes; in others on the inteftines of ferpents; and in others on the backs of tortoifes. (Mabill. de Re Diplom. lib. i. cap. 8. Fabric. Biblioth. Nat. cap. 21, &c.) There are few forts of plants but have at fome time been ufed for paper and books: and hence the feveral terms, *biblos*, *codex*, *liber*, *folium*, *tabula*, *tillura*, *philura*, *fcheda*, *&c.* which exprefs the feveral parts on which they were written: and though in Europe all thefe difappeared upon their introduction of the papyrus and parchment, yet in fome other countries the ufe of divers of them obtains to this day. In Ceylon, for inftance, they write on the leaves of the talipot. And the Bramin MSS. in the Tulinga language, fent to Oxford from Fort St. George, are written on leaves of the ampana, or palma Malabarica: Hermannus gives an account of a monftrous palm-tree called *codda pana*, or *palma montana Malabarica*, which, about the thirty-fifth year of its age, rifes to be fixty or feventy feet high, with plicated leaves nearly round, twenty feet broad; with which they commonly cover their houfes; and on which they alfo write; part of one leaf fufficing to make a moderate book. They write between the folds, making the characters through the outer cuticle. Knox. Hift. Ceyl. lib. iii. Le Clerc. Bibl. Univ. tom. xxiii. p. 242. Phil. Tranf. N° 246. p. 422, feq Vide Hort. Ind. Malab. p. 3. Phil. Tranf. N° 145. p. 108.

In the Maldive iflands, the natives are faid to write on the leaves of a tree called *macaraquean*, which are a fathom and a half long, and about a foot broad. And in divers parts of the Eaft Indies, the leaves of the mufa arbor, or plantain-tree, dried in the fun, ferved for the fame ufe, till of late that the French have taught them the ufe of European paper. Ray, in fine, enumerates divers kinds of Indian and American trees which bear leaves proper to be ufed as paper; particularly one called *xagua*, which has fomething in it extraordinary; its leaves are fo large, and of fo clofe a texture, that they cover a man from top to toe, and fhelter him from the rain, and other inclemencies of the weather, like a cloak: and from the innermoft fubftance of thefe leaves, a paper is taken; being a white and fine membrane like the fkin of an egg, as large as a fkin of our vellum or parchment, and nothing inferior for beauty and goodnefs to the beft of our papers. Vide Savar. D. de Comm. tom. ii. p. 967. Vide Ray Hift. Plantar. tom. ii. lib. 32. Nouv. Rep. Let. tom. xii. p. 361.

Paper is chiefly made among us of linen, or hempen rags,

beaten to a pulp in water, and moulded into ſquare ſheets, of the thickneſs required. But it may alſo be made of nettles, hay, turnips, parſnips, colewort-leaves, aſbeſtus, or any thing that is fibrous; nay, it may be made of white woollen rags: though this would not ſerve for writing, becauſe of the haırineſs. The Chineſe paper is ſo fine, that many of the Europeans have thought it was made of ſilk; not conſidering, ſays Du Halde, that ſilk cannot be beat into ſuch a paſte, as is neceſſary to make paper: but it is to be obſerved, that the ſame author afterwards ſpeaks of a paper, or parchment, made of the balls of ſilk worms; and the like, we are aſſured by others is done at Cathay. Hought. Collect. N° 360. tom. ii. p. 418, ſeq. Deſcript. of China, p. 360. ſeq. Vide Buſbeq. Legat. Turc. Epiſt. iv. p. 329.

PAPER, with regard to the manner of making it, and the materials employed therein, is reducible to divers kinds: as the *Egyptian*, *European*, and *Chineſe paper:* we alſo find mention of *cotton paper*, *bark-paper*, and *aſbeſtine* or *incombuſtible paper*.

PAPER, *Egyptian*, is that which was principally uſed among the ancients: it was made of a ruſh called papyrus, or biblus, growing chiefly in Egypt, about the banks of the Nile: though it was alſo found in India; and Guilandinus aſſures us, he ſaw in Chaldæa, at the confluence of the Tigris and Euphrates, large fens, in which, with his own hands he plucked a papyrus differing in nothing from that of the Nile. Strabo likewiſe ſpeaks of a ſort of papyrus growing in Italy; but we do not find this was ever uſed for making paper.

The deſcription given by Pliny of the papyrus, or paper-reed, is ſomewhat obſcure. Its root, according to him, is of the thickneſs of a man's arm, and ten cubits long; from this ariſe a great number of triangular ſtalks ſix or ſeven cubits high, each thick enough to be eaſily ſpanned; its leaves are long like thoſe of the bull-ruſh; its flowers ſtamineous, ranged in cluſters at the extremities of the ſtalks; its roots woody and knotty like thoſe of ruſhes, and its taſte and ſmell near akin to thoſe of the cyperus, under which genus Linnæus has claſſed the papyrus. (See CYPERUS.) Vide Plin. Hiſt. Nat. lib. xiii. cap. 11. Vide Theophr. Hiſt. Plant. lib. iv. cap. 9. and Delecamp, who gives us a figure of it, Hiſt. lib. xviii. p. 1883. See alſo Bauhin. lib. xviii. cap. 186, who, with Geſner, makes it a ſpecies of Cyperus. Grew Muſ. Reg. Societ. p. 2. ſect. 2. p. 225, ſeq. Maffei Iſtor. Diplom. Bibl. Ital. tom. ii. p. 246.

Beſides paper, they made ſails, ropes, and other naval rigging; as alſo mats, blankets, clothes, and even ſhips, of the ſtalk of the papyrus. Moſes, we are told, when a child, was expoſed on the banks of the Nile, εν θιβη παπυρυ, *i. e.* in a baſket of papyrus. The Egyptian prieſts wore ſhoes of papyrus.

Guilandinus, a Pruſſian phyſician before mentioned, has a celebrated work expreſsly on the ancient papyrus, by way of commentary on three chapters of Pliny, in which is amply, and with great learning, explained all that relates to this ſubject; yet Scaliger has written a ſevere critique on it, in which ſome inaccuracies of Guilandinus are pointed out; but this has not hindered Kirchmayer from adopting almoſt Guilandinus's whole book in his diſſertation on the papyrus. Add, that the moſt ingenious and learned count Scipio Maffei has lately vindicated Guilandinus againſt the exceptions of Scaliger, as well as of Voſſius and Hardouin. (Vide Iſtor. Diplomat, lib. ii. Bibl. Ital. tom. ii. p. 248. Melch. Guilandini Papyrus, h. e. Commentarius in tria C. Plinii Majoris de Papyro capita, ſc. lib. xiii. cap. 11, 12, 13, firſt publiſhed at Venice in 1572, and afterwards at Amberg, in 1613, by Salmuth.) It ſeems, Guilandinus intended a commentary on the whole of Pliny's Natural Hiſtory; but this ſmall part, not exceeding a moderate page, taking him up full ſix months, it is no wonder he was diſcouraged from proceeding with the reſt. In theſe three chapters he has reſtored about twenty paſſages in the text of Pliny, not merely from his own conjecture, or the help of MSS. but from the nature of the things deſcribed, and the teſtimonies of authors of the firſt rank: beſides that, he had been upon the ſpot, where formerly the papyrus was manufactured, and had carefully examined all the ancient Greek and Latin authors who ſpeak of it.

Joſ. Juſt. Scaligeri Animadverſiones in Melchioris Guilandini Commentarium in tria C. Plinii capita, lib. xiii. Hiſtoriæ Mundi ſive Naturalis, quibus agit de Papyro, firſt publiſhed in the Lectiones Bibliothecariæ Memorabiles, of Rudolphus Capellus, at Hamburgh, in 1682, where he follows Guilandinus ſtep by ſtep, finds as many faults in him as his father had done in Cardan, and uſes him altogether as coarſely; every where pointing out his literary miſtakes, and labouring to ſhew, that inſtead of reſtoring Pliny, he has often miſtaken and corrupted him. M. Seb. Kirchmaieri Uffenhaimenſis Franci Diſſertatio Philologica de Papyro veterum, Wittebergæ 1666, 4to.

He had done better ſervice, if, beſides Guilandinus, he had conſulted others, and particularly Scaliger. But as he choſe to follow one rather than many, and that too as the blind follow their guides, his fate has been much the ſame.

The origin of the art of making paper of the papyrus is very obſcure; no doubt it was firſt diſcovered in Egypt. Iſidore fixes it more particularly to the city Memphis, Orig. lib. vi. cap 10. in which he ſeems to be countenanced by Lucan, where he ſays,

> "Nondum flumineas Memphis contexere biblos
> Noverat———" Pharſal. lib. iii. v. 222

The era of this invention is warmly diſputed: Varro, the moſt learned of the Romans, fixed it to the time of Alexander the Great, after the building of the city of Alexandria by that conqueror; but ſeveral objections, of no ſmall weight, are brought againſt this deciſion. Pliny recites a paſſage out of a very ancient annaliſt, one Caſſius Hemina, wherein mention is made of paper books found in Numa's tomb, five hundred and thirty-five years after his death, which had been buried with him: now Numa was prior to Alexander by above three hundred years. Guilandinus, in effect, maintains, with great erudition, that the name and uſe of the papyrus were known to the Greeks long before Alexander conquered Egypt; and that the words βιβλος, and βιβλιον occur in their received ſignification in authors prior to, or at leaſt older than, Alexander: particularly Anacreon, Alcæus, Plato the comedian, Ariſtomenes, Cartinus, Antiphanes, Plato the philoſopher, Æſchylus, and Ariſtotle. And whereas ſome ſpeak of a kind of unknown pſeudo-biblos, in uſe before the diſcovery of the true ſort, he argues, on the contrary, that the biblos mentioned by thoſe authors, prior to the conqueſt of Alexander, appears from Herodotus, Theophraſtus, and others, to be the very ſame plant with the biblus, or papyrus, of which paper was afterwards made: even Homer and Heſiod, the moſt ancient Greek poets, and who by Herodotus's teſtimony lived about four hundred years before himſelf, appear to have been no ſtrangers to the papyrus, ſince they both make expreſs mention of it. Vide Plin. lib. xiii. cap. 13. Guiland. Papyr. Membr. 2. Reim. Idea Syſt. Antiq. Liter. p. 285, ſeq. Kirchman Diſſ. de Papyr. art. 11. ſect. 2.

To this it may be anſwered, that ſuppoſing the plant papyrus known in Greece long before Alexander's conqueſt of Egypt; it no more follows, that they had then the uſe of paper; than it follows, that men had wine immediately on the diſcovery of the vine.

In reality, Guilandinus produces teſtimonies, from Anacreon and Alcæus, in which the papyrus is employed for binding, and not for paper; add, that he ill tranſlates τυ φρεαλυχνον, *ellychnium;* ſince λυχνον here is the torch itſelf. Nor does the poet ſay it was made of papyrus, but tied up with it. Vide Scalig. lib. cit. Reimm. ubi ſupra, p. 305. ſeq.

Some have even doubted whether the art of manufacturing the papyrus was ſo ancient as Alexander's time; chiefly on this ground, that, for two hundred years after Alexander, men wrote on ſkins, and on the barks of trees: but this is nowiſe concluſive The ſcarcity of the new manufacture may account for it: for ſome ages afterwards, even as low as Tiberius, we read of ſuch a ſcarcity of paper, that its uſe, even in contracts, was diſpenſed with by a decree of the ſenate, and the opinion of the judges. The ſame conſideration may be carried farther: paper might have been known in Egypt, Judæa, Syria, and Aſia on this ſide Taurus, long before the birth of Alexander, though not in common uſe; but it might be later before the Europeans received it; and probably it was by means of Alexander's conqueſt that it firſt became publicly known there.

When the manufacture of the Egyptian paper ceaſed, is another queſtion; for, at preſent, the *papyrotechnia Ægyptiaca* may be reckoned among thoſe arts that are loſt. Euſtathius, the learned commentator on Homer, teſtifies, that even in his time, *viz.* in 1170, it was diſuſed: Mabillon, indeed, maintains, that it continued till the eleventh century after Chriſt; and cites one Fridegod, a monkiſh poet of the tenth century, as ſpeaking of it as ſubſiſting in the age before his, that is in the ninth; and that it continued longer, the ſame Mabillon endeavours to evince, from ſeveral papal bulls wrote on it as low as the eleventh century. Vide Euſtath. ad Homer. Odyſſ. φ. Voſſ. de Art. Gram. lib. i. c. 37. Vide Mabill. De Re Diplomat. lib. i. cap. viii. ſect. 6. ſeq. Reim. Idea Syſt. Antiq. Liter. p. 311.

Maffei, on the other hand, maintains, with more probability, that the papyrus was generally diſuſed before the fifth century; for that we find no authentic records, written on it, dated ſince that time; thoſe bulls of popes, cited by Mabillon, appearing rather to be written on cotton paper. But this, we may obſerve, relates only to the general and legal uſe of the papyrus. For that it ſhould have continued to be made by particular perſons ſeveral hundred years after it firſt began to give way, is not to be wondered at. Vide Maffei Iſtor. Diplomat. loc. cit. Bibl. Ital. tom. ii. p. 251.

In reality, a more commodious ſort of paper, made of cotton, having been invented ſome ages before in the Eaſt, and coming to be introduced into Europe, ſeems to have brought the papyrus into diſuſe. To which the continual wars with the Saracens, by which the traffic to Alexandria was rendered precarious, might poſſibly not a little contribute.

Yet ſeveral books, written on leaves of the papyrus, have even continued to our days: Mabillon ſays, he had one of them; and adds, that there was another in the Petavian library, being a volume in ſmall folio, containing ſeveral ſermons of St. Auguſtine; he alſo mentions a third, containing that father's epiſtles, formerly belonging to the church of Narbonne, and afterwards in the cuſtody of madame De Phirmacon; beſides the homilies of Avitus, biſhop of Vienne, and divers diplomas or charters, all written on the papyrus, which appear not to be leſs than eleven hundred years old. But the deciſions of this learned father concerning MSS., notwithſtanding all his diplomatic ſkill ſo highly boaſted of, are not always infallible; witneſs his taking the MS. of St. Mark's Goſpel, at Venice, to be written on the Egyptian papyrus; and that of Joſephus, at Milan, not to be ſo. Maffei ſhews, on the contrary, that the former is cotton paper; and that the latter appears, at firſt ſight, to be Egyptian; not but the Venetian MS. is very old; but it has been ſo much uſed, that its leaves are, as it were, transformed into the original paſte from whence they are made. Vide Mabill. Suppl. ad Libr. de Re Diplomat. Journ. des Sçav. tom. xxxii. p. ii. p. 992. Maffei, lib. cit. Bibl. tom. ii. p. 252. And Montfaucon. Paleog. Græc. p. 14.

Paper, *Manner of making the Egyptian.* They began with lopping off the two extremes of the papyrus, *viz.* the head and root, as of no uſe in this manufacture; the remaining ſtem they ſlit lengthwiſe into two equal parts, and from each of theſe they ſtripped the thin ſcaly coats or pellicles, of which it was compoſed, with the point of a penknife. The innermoſt of thoſe pellicles were looked on as the beſt, and thoſe neareſt the rind or bark the worſt; they were kept apart accordingly, and conſtituted different ſorts of paper.

Theſe pellicles are called, in Pliny, by twelve different names; *viz. philura, ramentum, ſcheda, cutis, plagula, corium, tænia, ſubtegmen, flatumen, pagina, tabula,* and *papyrus.*

The generality of critics, in lieu of a pen-knife, employ a needle to ſeparate the pellicles; in which they are warranted by the common text of Pliny, "Præparantur ex eo chartæ, diviſo acu in prætenues, ſed quam latiſſimas philuras." But Guilandinus makes a correction here: he had found, by experiment, that the pellicles of papyrus cannot be ſeparated by a needle; but that a very ſharp knife is required; for which reaſon, inſtead of *diviſo acu,* he reads *diviſo ſcapo.* In which he is followed by Maffei, though Hardouin, Voſſius, Pitiſcus, and others, retain the ancient reading. Vide Guiland. Papyr. Membr. 10. ſect. 3. and 5. Maffei Iſtor. Diplom. ap. Bibl. Ital. tom. ii. p. 247, ſeq. Voſſ. De Art. Grammat. lib. i. cap. 37. Pitiſc. L. Ant. tom. i. p. 413. voc. Charta. Hardou. ad Plin. lib. xiii. cap. 12.

As the pellicles were taken off, they extended them on a table; then two or more of them were laid over each other tranſverſely, ſo as that their fibres made right angles: in this ſtate they were glued together by the muddy waters of the Nile. Theſe, being afterwards preſſed to get out the water, then dried and laſtly flatted and ſmoothed by beating them with a mallet, conſtituted paper: which they ſometimes poliſhed farther by rubbing it with an hemiſphere of glaſs or the like.

In other countries where the waters of the Nile were not to be had, the pellicles were faſtened together with a paſte made of the fineſt wheat-flour, mixed with hot water, and a ſprinkling of vinegar.

The ingenious and learned count de Caylus, in his account of the papyrus, informs us, that the intermediate part of the ſtalk was cut and ſeparated into different laminæ, which were ſet apart, and dried in the ſun for the manufacture. Theſe laminæ were joined together horizontally or tranſverſely, in ſheets or leaves, upon a ſmooth board: then moiſtened with water, which diſſolved a kind of viſcous glue in the pores of the plant, ſerving to cement and render the whole uniform. The ſheet, being thus formed, was put into a preſs, and afterwards dried for uſe. Such,

he says, was the process of making paper in Egypt; but as the sheets were coarse, brown, unequal, and imperfect, the Romans invented methods to bring the fabric to perfection. They contrived a glue or gum, by means of which they could occasionally enlarge the size and volume. They bleached it to a surprising degree of whiteness; they beat it with hammers, so as to render it more thin and less porous; they smoothed and polished it with ivory; and by a sort of calender gave it a shining gloss, like that of the Chinese paper. According to the different degrees of delicacy, whiteness, and size, it acquired different appellations either from the names of particular manufactures, from the great personages who used it, or from the particular uses to which it was applied; such as the Fannian, the Livian, the Claudian, the Imperial, the Hieratic and the Amphitheatric.

There were paper manufactures in divers cities of Egypt; but the greatest and most celebrated was that at Alexandria, where, according to Varro's account, paper was first made. It is certain at least it was from hence that Greece and Italy was furnished, on account of the convenient situation of that port; and it is more than probable it was this that gave the Romans occasion to conclude the art had been invented there. It was not till late, when Egypt was reduced into a Roman province, that they had much intercourse, or even knowledge of the inland cities of Egypt, where paper was also made. The trade and consumption of this commodity were in reality incredible. Vopiscus relates, that the tyrant Firmus, who rebelled in Egypt, publicly declared he would maintain an army only with paper and glue, "papyro & glutine." This, Casaubon understands as spoken of the produce and revenue of paper; though Salmasius takes it to be meant of the papyrus itself, which could supply most of the necessaries of life. Vide Montfauc. Palæogr. Græc. lib. i. cap. 2. p. 14.

We find divers species of Egyptian paper mentioned in ancient writers: some denominated from the places where they were manufactured; as 1. The *Amphitheatrica*, supposed to have been made in some building belonging to an amphitheatre at Alexandria; though Guilandinus, with more probability, reads it *Arthribitica*, from Arthribus, a city in the middle of the Delta, which was the place of its manufacture. What countenances this correction, is, that we find mention of this paper before there was so much as an amphitheatre at Rome, much less at Alexandria. 2. *Saitica*, made in the city Sais. 3. *Tæniotica*, or, according to others, *Taitica*, whose place authors are not agreed on. There were also other sorts denominated from the makers; as 1. The *Fanniana*, from the grammarian Rhem. Fannius Palæmon, who kept a paper work. This kind was small, but finer than the Amphitheatrical paper; being first wrought at Alexandria, and afterwards finished at Rome. 2. *Claudia*, first made by order of the emperor Claudius. This was reputed the best of all, in that, besides the two pellicles, in common with the rest, it had a third. Others were denominated from the uses they were intended for; as, 1. *Hieratica*, the first or oldest sort, which was appropriated to religious uses; this was afterwards denominated *Augusta* and *Liviana*, in compliment to the emperor of that name, and his wife; who, according to some, improved and made it whiter than before. 2. *Emporetica*, or *Emporica*, a small and coarse sort, serving for shopkeepers uses, to tie up goods, &c. The qualities for which the ancient papers were prized, were their thinness, closeness, whiteness, and smoothness; though their breadth also considerably enhanced their value. That sort called *charta Claudia* was thirteen inches wide; the *Hieratica*, eleven; the *Fanniana*, ten; and the *Amphitheatrica*, nine; as to the *Saitica*, it exceeded not the diameter of the mallet it was beaten with.

See farther concerning the ancient paper, in Nigrisoli Diss. de Charta, ejusque Usu apud Antiquos. Ext. in Galer. de Minerv tom. iii. p. 249, seq. Other authors are enumerated in Fabric. Bibl. Antiq. cap. xxi. sect. 9. p. 609. Pitsc. L. Ant. loc. cit.

Paper, *Bark*, if it may be so called, was only the *liber*, or inner whitish rind enclosed between the outer bark and the wood of divers trees, as the maple, plane, beech, and elm, but especially the *tilia*, φιλυρα, or *linden-tree*, which was that mostly used for this purpose. On this, stripped off, flatted, and dried, the ancients wrote books; several of which are said to be still extant. Vide Plin. Hist. Nat. lib. xiii. cap. 11. Hardou. Not. ad eund. Suid. Lex. in voc. φιλυρα. Isid. Orig. lib. vi. cap. 13. Alexand. ab. Alexand. lib. ii. cap. 30. Salmuth. ad Pancirol. lib. ii. tit. 13. p. 252, seq.

Mabillon and Montfaucon speak frequently of manuscripts and diplomas on bark, and are very express in distinguishing between the papyrus used by the Egyptians, and the liber or bark in use in other countries. The two are alleged to differ in this, that the bark paper was thicker and more brittle than the papyrus, as well as more apt to cleave or shiver, by which the writing was sometimes lost; as is the case in a bark manuscript in the abbey of St. Germain's, where the bottom of the paper remains, but the outer surface, on which the letters had been drawn, is in many places peeled off. Vide Montfauc. Palæogr. Gr. lib. i. cap. 2. p. 15. Mabill. de Re Diplom. lib. i. cap. 8. Reimm. Idea Syst. Antiq. Liter. p. 311.

But Maffei, it must not be forgot, combats the whole system of bark manuscripts and charters as a popular error; and maintains, that the ancients never wrote diplomas on bark; that the distinction between the papers made of papyrus and of cortex, is without foundation; that the only use of the tilia, or linden, was for making thin boards or tablets for diptycha or pocket-books, wherein they wrote on both sides, as is done among us: an advantage which they could not have in the Egyptian paper, by reason of its thinness.

A late French writer on the rules of criticism wanders still farther out of the way, when he speaks of a sort of paper, in Egypt, made of the pith of the cyprus: he describes the manner of preparation, which was by reducing this pith to a pulp, and then spreading it out in leaves. Vide Hon. St. Marie Reflex. sur les Regl. de la Crit. tom. ii. diss. 77. This we suspect for a chimera hatched only in the critic's brain.

Not but there occur divers anomalous sorts of paper, which antiquaries are not a little puzzled what species to refer them to; such is that of two bulls in the archives of the church of Gironne, issued by the anti-popes Romanus and Formosus, between the years 891 and 895. They are two ells long and one broad; and consist of two leaves or pellicles glued together transversely, and are still legible in most places. The conjectures of the French literati, in regard to these, are numerous; the abbot Hiraut de Belmont has a discourse express on the occasion. Some will have them made of the leaves of the *alga*, or sea-wreck; others of the leaves of a rush, called *la boga*, growing in the marshes of Rousillon; others of papyrus; others of cotton; and others of bark. So little certainty does there really appear to be in these things, on which the critics nevertheless often lay a great stress. Vide Mem. de Trev. Sept. 1711. p. 1559, seq.

Paper, *Cotton*, *charta bombycina*, βομβυκινη (thus called

from $\beta o\mu\beta v\xi$, a word which anciently ſignified *ſilk*, though in after-times $\beta o\mu\beta v\xi$ and $\beta \alpha\mu\beta v\xi$ came to denote *cotton*), is a ſort of paper which has been in uſe upwards of ſeven hundred years ago, as is ſhewn by Montfaucon from ſeveral authorities; what is more, cotton paper appears to have been very common at the beginning of that time, and conſequently muſt have been invented long before, probably about the cloſe of the ninth, or the beginning of the tenth century.

In the French king's library are MSS. on this paper, which, by the character, and other circumſtances, appear to be of the tenth century. Be this as it will, from the twelfth century, cotton MSS. were more frequent than parchment ones. Vide Montfauc. Palægr. Græc. lib. i. cap. 2. p. 17, ſeq item, lib. iv. cap. 6. p. 209. Maffei, lib. cit. Bibl. Ital. tom. ii. p. 252.

Paper, *Incombuſtible*, is made of the lapis aſbeſtos, or linum vivum, which will bear burning without being injured.

Dr. Bruckman, profeſſor at Brunſwick, has publiſhed a natural hiſtory of the aſbeſtine, or incombuſtible paper; and, what is moſt remarkable, has printed four copies of his book on this paper: they are depoſited in the library of Wolfembuttel. Vide Bibl. Germ. tom. xiv. p. 190.

The manner of making this extraordinary paper is deſcribed by Mr. Lloyd, from an eſſay made by himſelf. He pounded a quantity of the aſbeſtos in a ſtone mortar, till it became a downy ſubſtance; then ſifted it in a fine ſearce, and by this means purged it indifferently well from its terrene parts; becauſe the earth or ſtones he could not pick out of it before, or at the pounding, being reduced to a powder, came through the ſearce, the linum remaining. This done, he brought it to the paper-mill; and putting it in water, in a veſſel juſt big enough to make a ſheet with ſuch a quantity, he ſtirred it pretty much, and deſired the workmen to proceed with it in the uſual method, with their writing-paper mould; only to ſtir it about always before they put their mould in; conſidering it as a far more ponderous ſubſtance than what they uſed; and that conſequently, if not immediately taken up after it was agitated, it would ſubſide.

The paper made of it proved but coarſe, and was very apt to tear; but this being the firſt trial, there is reaſon to believe it might be much improved; nor did the workmen doubt, but in caſe it were pounded in one of their mortars, for twenty hours ſpace, it would make good writing-paper. Vide Phil. Tranſ. N° 166. p. 824. See Asbestos.

Paper, *Linen* or *European*, is chiefly made of linen rags beaten to a pulp with great hammers, and the ſoil carried off by a continual ſupply of freſh water, conveyed among the pulp in little troughs, till it be rendered perfectly white.

Beſides the chief uſe of this paper, which is for writing and printing, there is a great conſumption of it in packing up goods, and on other occaſions.

The manufacture of paper has got footing in moſt countries; though France, Holland, and Genoa, are the places where it has ſucceeded beſt. In the general it depends much on the quality of the linen worn in the country where it is made; where that is coarſe and brown, &c. the rags, and conſequently the paper made of them, muſt be ſo too. Hence the whiteneſs of the Dutch and Flemiſh papers, beyond the Italian and French, and much more the German papers. The Engliſh manufacture was a long while in no great reputation; but it is every day improving; inſomuch that we now import little of the ordinary ſorts, which were formerly all brought from abroad. Yet paper-mills are of ſome ſtanding among us. We find one erected at Dartford as early as the year 1588, which we believe was the firſt, and which is celebrated by a noted poet of that age, Tho. Churchyard, in a work in verſe, intitled "A Deſcription and Diſcourſe of Paper, and the Benefits it brings; with the ſetting forth of a Paper-mill, built near Dartford, by a High-German, called Mr. Spilman, Jeweller to the Queen, Lond. 1588. 4to."

In reality, the deficiency of the Engliſh paper manufacture did not ſeem owing ſo much to the quality of our rags, as to the want of ſkill and attention in the makers; but the manufacture of paper has been very conſiderably encouraged in our country, and has already arrived to a great degree of perfection.

Anderſon, in his Hiſt. of Com. vol. ii. p. 197. ſays, that till about the year 1690, there was ſcarcely any other kind of paper made in England, but the coarſe brown ſort. But the war with France occaſioning high duties on foreign paper, the French Proteſtant refugees ſettled in England chiefly, and alſo our own paper-makers now began to make white writing and printing paper, which, he adds, in length of time, has been brought to ſo great perfection, both for beauty and ſubſtance, that in our own time we import only certain kinds of Genoa and Dutch paper, which bears but a very ſmall proportion to all the paper uſed in the Britiſh dominions. This has produced, it is ſaid, a ſaving to Britain of 100,000*l.* which was paid annually to France for paper only.

Another writer ſays, that the Engliſh manufactures now provide above ſeven-eighths of the whole quantity of paper conſumed in Great Britain.

When and by whom linen paper was invented is a ſecret, which Polydore Virgil owns he could never trace. Scaliger will have it to have been found out by the Germans. Maffei affirms it certain, that the invention is owing to the Italians. Others aſcribe it to ſome refugee Greeks at Baſil, who took the hint from the manner of making cotton paper in their own country. Conringius takes the Arabs to have firſt brought it among us. Perhaps the Chineſe have the beſt title to the invention; who for many ages have made paper much after the ſame manner; and even, in ſome provinces, of the ſame materials, *viz.* hemp, &c. Vide Polyd. Virg. de Inventor Rer. lib. ii. cap. 8. Secund. Scaliger. p. 7. Fabric. Bibl. Antiq. cap. 9. ſect. 21. Iſtor. Diplom. lib ii. Bibl. Ital. tom. ii. p. 253. Phil Tranſ. N 288. p. 1515. Conring. Epiſt. ap. Act. Erud. Lipſ. an. 1720. p. 94. Savar. D. Comm. tom. ii. p. 963. Du Hald. Deſcr. Chin. tom. i. p. 363.

Linen paper appears to have been firſt introduced among us towards the beginning of the fourteenth century.—The learned Conringius denies, that there are many manuſcripts of this paper above four hundred years old; with whom agrees the count Maffei, who finds no marks of its uſe before the year 1300. Vide Conring. Epiſt. ap. Act. Erud. Lipſ. an. 1720. p. 94. Maffei Iſtor. Diplom. lib. ii. Bibl. Ital. tom. ii. p. 253.

Some indeed go much farther back; and take the *libri lintei*, mentioned by Livy, and other Roman writers, to have been written on linen paper; but Guilandinus, and after him Allatius, and others, have ſufficiently refuted this notion; and ſhewn, that the *libri lintei* were written on actual pieces of linen cloth, or canvas, prepared for this purpoſe, ſuch as painters ſtill uſe; and not on paper made of linen rags. Vide Liv. Dec. 1. lib. iv. Plin. Hiſt. Nat. lib. xiii. cap. 11. Priſc. L. Ant. tom. ii. p. 85. Guiland. Papyr. Memb. 25. Salmuth. ad Pancirol. lib. ii. tit. 13. p. 253.

Others run into the contrary extreme, and make paper the invention of a very late date. The Jeſuit Inchofer dates

its origin about three hundred years ago; with whom agrees Milius, in his "Hortus Philosophicus," who maintains, that the art of making paper was not invented till about the year 1470. Of the same opinion seems Ray, who tells us the art of making this paper was not known in Guernsey till the year 1470, and when two persons, named Anthony and Michael, first brought it to Basil, out of Galicia in Spain. In effect, if the invention be owing to the refugee Greeks at Basil, who fled thither after the sacking of Constantinople, it must at least be posterior to the year 1452, when that city was taken. Some add a farther argument for the novelty of paper, drawn from the novelty of hempen cloth, which Rabelais, who died in 1553, mentions as first found out about a hundred years before him; and which was so scarce in the time of Charles VII. of France, who died in 1461, that the queen, his wife, was the only woman in France that had a couple of shifts of it. Vide Mabill. de Re Diplom lib. i cap. 8. Reimm. Idea Syst. Antiq. Liter. p. 313, seq. Balbin. Miscell. Hist. Bohem. cap. 22. Act. Erud. Lips. 1682. p. 243. Ray Hist. Plant. lib. xxii. Phil. Trans. N° 288. p. 1515. Naudæan. p 82. Nouv. Rep. Let. tom. xxvi. p. 571.

But these suggestions are refuted by Mabillon, from the testimonies of writers prior to the time here spoken of, and from many manuscripts of about four hundred years old, which are written on linen-paper. The Jesuit Balbinus produces divers instances of paper manuscripts, written before the year 1340. An ingenious writer of our own country assures us, he had a piece of paper which agreed well with the charter dated in 1358, in the thirty-second year of Edward III. He adds, that in the archives of the library belonging to the dean and chapter of Canterbury, is an inventory of the goods of Henry, prior of Christ-church, who died in 1340, written on paper; and that in the Cotton Library there are several writings on our paper, in the times of most of our kings and queens, as high as the fifteenth of Edw. III. which coincides with the year 1335. And Dr. Prideaux assures us he has seen a registration of some acts of John Cranden, prior of Ely, made on paper, which bears date in the fourteenth year of king Edward II. that is, anno Domini, 1320. Mabill. loc. cit. Balbin. lib. cit. Phil. Trans. N° 288. p. 1515. Prid. Connect. p. 1. l. 7. p. 710.

Add, that the invention of paper may appear more modern than it is, because records were not used to be written on it, but it was a considerable time confined to letters, and other fugacious compositions; which is so true, that, to this day, few instruments of any consequence are written on it, though it have been so long in use. It is even alleged, that Peter, the venerable abbot of Cluny, who died in 1157, has a passage in his book against the Jews, which plainly indicates paper books to have been then known; on the authority of which Valesius, in his notes on the panegyric of Berengarius Augustus, scruples not to make paper upwards of 500 years old.

Father Hardouin assures us, he had seen records or diplomas on it prior to the 13th century. But this will hardly be credited. Count Maffei assures us, that in all his researches he could never meet with one more ancient than the year 1367. It is highly probable the learned Jesuit mistook a cotton manuscript for a linen one: a mistake easily made, as the chief difference between the two consists in the greater thinness of the linen paper. But it is known we have linen papers of very different degrees of thickness; and the like may be said of those of cotton. Vide Maffei Istor. Diplom. lib. ii. Bibl. Ital. tom. ii. p. 253, seq.

The invention, according to Prideaux, seems to have been brought from the East; because most of the old manuscripts, in Arabic, and other Oriental languages, are written on this sort of paper; some of which are certainly much older than any of the dates above-mentioned. This author thinks it most probable, that the Saracens of Spain first brought it out of the East into that country; from whence it was propagated through the rest of Europe.

PAPER-*Making*. Nature presents us, as we have already observed, with a variety of substances from which paper may be made, as linen or hempen rags, the stalks of nettles, straw, hay, and the down of thistles. It may be also made of cotton, or white woollen rags, though such paper would not serve for writing, because of its hairiness. Of all these substances, linen or hempen rags alone are employed by the manufacturers, except a small quantity of cotton rags, which are sometimes mixed with the linen for inferior purposes.

The chief process of making paper consists in separating the fibres of the rags, by grinding, into exceedingly fine and short filaments; which being mixed with water, till they make a fine pulp, may be taken up in a very thin and even layer upon a mould of wire cloth. Now by the draining away of the water through the wire, the filaments are left, interwoven or felted so completely among each other, that they will not separate without breaking, and when dry will make a sheet of paper; the strength and quality of which depend very much upon the materials it is made from, and the equality of length and size to which the filaments are reduced by the grinding, which equality alone can cause them to float equally in the water of the pulp, and thus distribute themselves fairly and equally over the wire mould when taken up by it. For writing paper, a fine white colour is necessary, and this is obtained either by using the whitest rags by themselves, or by a chemical process of bleaching.

The incalculable advantages which the moderns have derived from the art of printing, would have been only imperfectly known, but for the invention of linen rag paper. A more plentiful and economical substance could not be conceived than the tattered remnants of our cloths, linen worn out, and otherwise incapable of being applied to the least use, and of which the quantity every day increases: nor could a more ready operation be imagined, than a few hours tritulation in a mill. It has been observed by a French writer, that the dispatch of the processes of paper making is so great, that five workmen in a mill may furnish sufficient paper for the continual labour of 3000 transcribers.

The art of printing would have been comparatively of little importance, without having the means of procuring a proper material to receive the impressions. Whilst the Egyptian papyrus was the only kind of paper, it would have been impossible to have procured it in sufficient quantities to have made large editions of books. The cotton paper, though in a progressive stage of improvement, was but a rude and perishable article, unfit for any of the nice purposes to which paper is now applied.

The perfection of the art of paper-making depended upon finding a material which could be procured in sufficient quantities, and which would be easy of preparation. Such is the paper now in use, of which we shall endeavour to describe the manufacture.

The operation of paper making admits of three divisions, *viz.* the preparation of the rags, the forming of the sheets, and the finishing of the paper. The succession of the several processes is as follows: 1. The rags are washed, or dusted, if they are dirty; then sorted into many qualities proper for different purposes. 2. The rags are bleached, to render them white; but this operation is sometimes deferred to the next stage of the process. 3. The washing engine of the paper

mill is employed to grind the rags, in water, till they are reduced to a coarfe or imperfect pulp, called *half ftuff*, or *firft ftuff*, in which ftate the bleaching is fometimes performed; or at other times it is bleached in the wafhing engine during the grinding. 4. The *half ftuff* is again ground in the beating engine, and water added in fufficient quantity to make a fine pulp, which being conveyed to the vat, the preparation of the rags is completed, and the pulp or ftuff is ready for making the fheets. 5. This is done by a workman who takes up a quantity of pulp upon a mould of fine wire cloth, through which the water drains away, and the pulp coagulates into a fheet of paper. 6. Another workman takes the fheet of paper off from the wire mould, and receives it upon a felt; he then covers it over with a fecond felt, evenly fpread out; and continues this operation, which is called *couching*, till he has made a pile of fheets called a *poft*, containing fix quires. 7. The poft of paper, with the felts, is placed in the *vat-prefs*, and the whole is fubjected to a ftrong preffure, to prefs out the fuperfluous water, and give the paper a folidity and firmnefs it would not otherwife have. 8. The pile of paper is removed from the vat-prefs, the felts taken out from between the fheets, and they are preffed again by themfelves, for a certain time, in a fcrew prefs. 9. The fheets are taken from the prefs, and hung up, five or fix together, on lines in the drying loft, till dry. The paper is now made, and only requires to be finifhed; but it fhould be obferved, that the greater number of the proceffes of finifhing are only performed upon fine writing paper, common printing paper being ready for packing up when dried. 10. The paper, in five or fix fheets together, is dipped into a tub of fine fize, and afterwards preffed to force out the fuperfluity; it is then dried again in the drying loft: but in printing papers this procefs is rendered unneceffary, by fizing the ftuff whilft in the engine, and adding certain ingredients. 11. An examination of each individual fheet of the paper is made, all knots and burrs are removed, and the bad fheets taken out. 12. A very large pile of paper is made, and preffed with a moft immenfe force, to render the fheets flat and fmooth. 13. The pile is taken down, fheet by fheet, and another made, without turning the fheets over: by this means new furfaces of the fheets are brought in contact with each other, and the pile being again fubjected to the prefs, the furface of the paper is improved. This operation is called *parting*, and is repeated two or three times for the beft papers. The paper is now counted into quires, folded and packed up into reams for market.

The ftrength and tenacity of paper depend upon the ftaple or fibre of the materials from which it is made. Rags of new cloth, and cordage, compofe a tougher and ftronger paper than old rags, which make a foft and pliable paper. The firft of thefe materials prefents a great variety, on account of the quality of the hemp or flax of which it is fabricated. Rags of fine new cloth, whether raw or bleached, ftand in the firft rank, after which old rags, cordage, &c. may be claffed.

The forting of the rags is of no fmall importance in the art of making paper; for unlefs the rags, which are ground at the fame time in the engine, are all of the fame quality, both as to fubftance and condition, the fineft and beft parts will be ground away in the mill, and carried off by the water before the coarfer are fufficiently reduced to make a fine pulp. For this reafon, in the forting of the rags which are intended to make fine paper, the hems and feams fhould be kept apart, and the coarfenefs of the cloth fhould be confidered. That cloth which is made of tow, fhould be feparated from that which is made from the longer fibres; cloth of hemp from cloth of flax; and laftly, the degree of wearing in the cloth fhould be attended to. For if rags, almoft new, are mixed with thofe which are much worn, the one will not be completely reduced to a pulp, whilft the other will be fo attenuated as to be carried off by the water, and pafs through the hair ftrainers of the engine; hence there muft be a confiderable wafte in the operation, a real lofs to the manufacturer, and even to the beauty of the paper; for the particles firft carried off by the current of the water, are perhaps thofe which give it that fmooth velvet foftnefs which is fo great a recommendation. When the forting is imperfectly performed, the pulp or ftuff is found to have cloudy parts floating in it, owing to fome maffes being lefs reduced than others. This produces thofe cloudy papers wherein are feen by intervals parts more or lefs clear, and more or lefs weak, occafioned by flakes affembled on the wire of the mould, which are not fufficiently tempered and diluted to incorporate with more fluid parts.

But as it is neceffary, in many cafes, to mix the different qualities of rags together, to produce various kinds of paper, this fhould be done by reducing the different forts of rags feparately in the mill, as alfo the hems and threads of the ftitching, becaufe the fewing thread, being never fo much worn as that of the cloth, and not fo eafy to be reduced, forms filaments in the paper. When the rags, unequally difpofed for trituration, have been ground apart, the different pulps may be mixed together without inconvenience, and will be found homogeneous or alike, each having been ground during the time that was neceffary for the ftate of the rag.

Without this precaution the fineft particles will be always loft, and of courfe the beautiful quality of the paper will be altered by the coarfeft. Therefore this care in forting the rags produces a great beauty of the paper, without hurting its goodnefs. It will, befides, be attended with the advantage of mixing a pulp, which will form the ftrength of the paper, with another which will give it foftnefs and luftre; and thus two qualities may be united which otherwife exifted feparately.

There are people in London, who, by dealing very extenfively in rags, have it in their power to obferve thefe precautions in forting, and to fell feparately all the different qualities to the paper makers. The fame may be faid of thofe great manufacturers who have the perfections of their work at heart. As to fmall country mills, it is fcarcely poffible for them to make fo great a choice. They are often obliged to lay up for fine many rags which are properly middling, and their middling may with better reafon be referved for making the coarfer fort of paper.

The people who go about the ftreets to buy up rags and old garments, fell them to the great dealers, who for the London market employ women to fort them into five forts, which are denominated Nos. 1, 2, 3, 4, and 5, according to their refpective qualities. No. 1 being fuperfine, and wholly linen, is ufed for the fineft writing papers. The other forts have different degrees of finenefs down to No. 5, which is completely canvas, but is proper for making inferior printing papers, when it has been bleached to a good colour. There is alfo rag bagging, which is the materials of the ftrong canvas facks the rags are fewed up in for carriage; and coloured rags, which confift of cotton, and are of all colours promifcuoufly mixed; but the blue are generally forted out, for the purpofe of making blue paper. The rag bagging and cotton rags are only fit for common papers. The rags are firft put into a machine, called a *dufter*, made in the form of a cylinder, four feet in diameter and five feet in length. It is all through covered with a wire net, and put in motion on pivots at its ends by a connection with fome

part of the machinery. The whole is inclofed in a tight clofe box to keep in the duft. A convenient quantity of rags, before the forting, is inclofed in the cylinder of the dufter, and the rapidity of its motion feparates the duft from them, and it paffes through the wires into the box. It is of confiderable advantage to ufe the dufter before forting, as it makes that operation lefs pernicious to the people.

The forting is performed by women and children, who are feated on benches, in a large room full of old linen, before a cheft or box, which is divided into fix cafes, to receive as many different forts of rags. Each woman has a piece of pafteboard, hung from her girdle, and extended on her knees, upon which, with a long fharp knife, fhe unrips feams and ftitches, and fcrapes off all filth.

Whatever can be ufed, after being well examined, is diftributed into one of the fix cafes, according to the degree of finenefs, and the women throw the reft at their feet. The fix cafes are for the fix different forts of rags: the fuperfine; the fine; and ftitches of the fine; the middling; the feams, and ftitches of the middling; and the coarfe; without including the very coarfe parts, which are totally rejected, at leaft for the making of white paper, but may ferve for white-brown paper; but even for this purpofe they fhould be mixed up with a large parcel of coarfe linen. Old paper may alfo ferve for the fame ufe, but the wafte is confiderable; it is therefore referved for pafteboard, in the manufacture of which, the ftuff being worked lefs time in the engine, and with lefs force, though with the fame water, it will lofe much lefs than if worked fufficiently to make paper. Befides, paper that has been once fized ftill gives the pulp a vifcidity, which ought to be guarded againft, as it prevents the fibres floating fo completely detached in the water as is neceffary to make them diftribute themfelves fufficiently equal and regular upon the wire mould, to make a true and even fheet of paper.

Paper intended for bills of exchange, or other commercial and legal inftruments, ought to be tough, in order that it may not be eafily torn, when made as thin as it is neceffary to be, for the eafe of conveyance by poft. For this, paper materials of the beft quality muft be entirely, or in large proportion, employed; and the price which the confumers are difpofed to pay for the article is fufficient to allow the beft materials, and ftill indemnify the manufacturer for his care and induftry.

Common papers alfo require to be more or lefs tough, according to their thicknefs, and the ufe to which they are applied; but a clear white colour is fought in paper of every defcription, whether for writing or printing. The manufacturers of paper were formerly obliged to attend to the colour of the rags in the forting, as well as to their qualities; but of this care they are now in a great meafure relieved, by the introduction of bleaching, which enables them to produce the fineft paper, in point of colour, from any kind of rags. They have only therefore to find fuch materials as will make paper of a ftrong texture, and a fine even furface, knowing they can produce colour at pleafure. To bleach the rags by the oxymuriatic acid gas, they are firft wafhed in hot water, by a fulling mill, fuch as is ufed for fcouring cloth: this removes the dirt, and they are put into a receiver or chamber, made of wood, in a cubical form, and the joints air tight. It is provided with feveral ftone retorts, which being filled with a mixture of manganefe, with two-thirds its quantity of fea-falt, and a quantity of fulphuric acid equal to the falt, will, when moderately heated by a fmall fand-bath furnace, throw into the receiver a gas which quickly difcharges any colour the rags may contain. This procefs, which is very fimilar to that ufed for bleaching cotton thread, was invented by Mr. Campbell, who had a patent for it in 1792. In his fpecification, he directs that the rags fhould, before they are put into the receiver to be bleached, contain about their own weight of fair water, the fuper-abundant water being preffed out. The rags fhould firft be opened by a machine, called by the cotton manufacturers a *devil*, or fome machine, of that nature, and they are to be diftributed in the receivers, in layers fpread on frames, fo that they will not come in contact with each other, or they may be placed in the body of the receiver, and have ftirrers or agitators, provided to expofe every part of them to the action of the bleaching gas.

After the procefs, which muft be concluded as foon as ever the rags are fufficiently bleached, left the gas fhould act upon and injure their quality, they are to be wafhed in water, and will be ready for the mill. Some manufacturers think that this mode of bleaching the rags makes them rotten, and injures the quality of the paper, which it certainly does if carried too far, though there is no doubt of the advantages of the procefs if well conducted.

The bleaching procefs has given rife to great complaints from the printers, as many printing papers are now made from cotton rags. The oxygenated muriatic acid being applied for the purpofe of obtaining difpatch and delicacy of colour, produces a paper of a good appearance from inferior ftaple. Nothing can be more perplexing to a printer, nor more detrimental to his labours, than this kind of bleached paper; for although it may be thick, and feem ftrong in the ream, no fooner does the water penetrate through it, than it lofes its adhefive quality, and becomes fo loofe and foft as fcarcely to bear handling, and in working under the prefs finks down into the cavities of the letters, leaving a part of its fubftance behind, after every impreffion, until it fo clogs the type, that the work is rendered fcarcely legible. Nor is it lefs exceptionable in point of durability, as it muft moulder away in a little time, with the common ufe that popular books generally undergo. Notwithftanding this it muft be allowed, that if by bleaching the paper makers can produce a bad article from fuch materials as were otherwife of no ufe, they are alfo able to improve their manufacture when they ufe the fame materials as formerly. It is found moft advantageous to bleach the rags in the ftate of half ftuff, that is, when they have been once worked by the mill, as the fibres being by that means feparated, the gas has greater accefs to the interior parts, and they are bleached quicker, fo as to have lefs danger of injury to particular parts, by too long an action of the gas. Another method of bleaching is by muriat of lime put into the wafhing engine, which for printing papers is the beft mode of any. We fhall defcribe it in the procefs of wafhing.

The engines now ufed in the paper mills are conftructed on fuch a powerful principle, that they are capable of reducing the ftrongeft and tougheft rags to pulp in a moderate time; whereas the old machines were not able to work the rags without *fermenting* them, as a previous procefs. The following extracts from a French work, on the art of making paper, will fhew the manner in which it was conducted 60 years ago.

" The rags, being forted, are put into a large ftone vat, fixteen feet long, ten broad, and three deep; water is poured upon them to the top during ten days, and eight or ten times every day without ftirring them. They are afterwards left to reft the fame number of days, and fometimes more or lefs, without pouring water upon them. Then being turned over, the centre is brought to the furface, to facilitate the fermentation; and after being turned again, they are ftill left fifteen or twenty days in fermen-

tation, so that the rotting may last five or six weeks; the term is not fixed, but when the heat becomes so great, that the hand, thrust in, cannot endure it above some seconds, it is judged that it is time to stop it.

"In mills, which have but few rags to work upon, they are left to rot longer, because the heaps being smaller, heat less, and with more difficulty; so that nothing can be justly determined of the time proper for the rotting part. It depends also on the quality of the rags; the finest linen does not rot so soon as the coarse; and linen that has been worn with more difficulty than new, because the internal humidity, that disposes the fibres to fermentation, is more considerable in new or coarse, than in fine or worn linen. Such as are more or less strong, more or less worn, resist the action of rotting in different degrees, some being spoiled, when others have not gone through the first fermentation: so that the rags, which have been sorted with great care, ought to be left to rot together, to avoid the risk of altering the whole parcel, by the mixture of a portion of rags quite different from the rest. When champignons grow on the heaps of rags, it is reckoned to be a sign of their being well rotted

"Besides this, there is another method for disposing of the rags in the place for rotting and fermenting them. Having been wetted with water, a heap is made of them in a corner of the vaulted room, which is destined for that purpose. They are watered from time to time, and when sufficiently heated, are transported into another angle of the same room, so that what was at the top of the first heap, is now laid under the second, and care is taken to throw water upon them from time to time. When this heap takes heat again, it is transported to the third corner, where, having fermented again, it is carried into the fourth angle; observing always to lay those rags under the heap that were at the top of the foregoing, and to water them often, for a reddish water will come from them, which it is very necessary to clear the rags of. When the heap in the first corner is brought away, another is formed in the same corner, which passes in its turn to the several corners of the room.

"Some, to accelerate the operation of rotting and fermenting, throw lime upon the rags. Perhaps a very small quantity of lime may be used: but if too much is laid on, the corroded rags will be too soon reduced into a pulp, and will pass through the strainer with the water, which ought to carry off only their filth, and will occasion a considerable waste. The use of lime, for the purpose of rotting rags, is absolutely prohibited in France.

"Fermentation, or rotting, makes the paper even, curdled as it were, soft, and gives it weight; if stopped too soon, the paper becomes crude, hard, light, stiff, requires more time to be worked, and the fecula, or pulp, does not so easily form a coagulation on the wire of the mould. It is sometimes observed, in regard to good rags that have not rotted, that the fecula is, as it were, enveloped in a viscid substance, which prevents its uniform precipitation; and this proves that rotting helps to clear off the unctuous matter in rags. If, on the contrary, the rags were left to ferment too long, a considerable waste would be occasioned, and more matter required for the same quantity of paper, because the parts attenuated by fermentation, would be too readily carried off by the washing. And lastly, if they were left to heat too long, they would be reduced to dust, and burn into smoke and ashes."

The action of rotting was, at that period, thought necessary for abridging the labour of making paper, and facilitating the operation of the mill; but several advantages are procured by dispensing with it, now we are able to destroy the texture of the cloth and reduce it to pulp, without previously corrupting its substance by rotting it; the paper is much stouter, is less liable to break, and is also whiter, for the fermentation gave a yellowish hue to the surface of the rags, which the mill could not take out without difficulties, and never could entirely, if the rags were too rotten.

We now come to describe the structure of paper mills. In England they now work with cylinders, or engines, an invention which was brought from Holland many years ago, and found to be so great an improvement, that it has been universally adopted. The old mills, which are still in use in some parts of the continent, actuate a number of stampers, or pestles, which pound the rags in wooden mortars till they are reduced to a pulp. These mortars are cut out in a block of heart of oak, well seasoned, the cavity being of an oval figure, about eighteen inches broad, thirty inches long, and eighteen or twenty in depth; the bottom concave, and lined with an iron plate an inch thick, eight inches broad, and thirty long, shaped inwards like a mould for a salmon, with the head and tail rounded. In the middle of the mortar is a cavity beneath the plate, and four or five grooves are cut, forming channels which lead to a hole cut from the bottom of the cavity quite through the block: it is covered by a piece of hair sieve fastened on the inside. This plate is grooved to make teeth, on which the teeth of the hammers act, to cut the rags in pieces. The use of the hair sieve is to prevent any thing from going out except the foul water. Two hammers or pestles work side by side in each mortar, and are lifted alternately by the mill: they are sometimes made in the same manner as the stampers of an oil mill, to lift perpendicularly. In other mills they are large hammers moving on a centre like a fulling mill, and lifted by cogs upon the mill shaft in the same manner. The mortars are kept constantly supplied with fair water, by little troughs, leading from a cistern, which is kept full by small buckets affixed to the floats of the water-wheel; these, when they have raised the water to the top, pour it out into the cistern, in the same manner as the Persian wheel.

This rude and imperfect machine operated very slowly, and suffered a great part of the rags to escape being reduced, whilst other parts were beaten too much. It is not now to be met with in England, the Dutch *engines* having taken their place, to the great improvement of the paper trade; these are turned by water mills, as they require a very great power to actuate them, though their performance is far greater, with the same power, than the mortars.

The construction of the mills is varied in different situations; but to explain the best kind, we have in *Plate* I. *Paper Mill*, given a drawing of one made with iron wheels, *fig.* 1. being an elevation, and *fig.* 2. a plan: the same letters of reference are used in both. The water-wheel which gives the motion cannot be seen, as it is situated beneath the floor, but its dimensions are marked by four dotted lines AAAA: in the plan it is enclosed between the three walls of the house P P R, and a fourth wall Q, which is built up across the house, to support the floors N and O, on which the engines stand: the wall R has arches in it to admit the water of the stream to the wheel, a proper gate being fixed to regulate its quantity: the axis of the water wheel, which is of cast iron, comes through the wall Q, and has a large cog-wheel B upon it, which is the full size of the water wheel, and by the paper makers is termed the *master-wheel;* the extreme end of the shaft is sustained in a bearing, which lays on a beam G G, supported on a wall of masonary. The pinion C, called the

wallower, is turned by the maſter-wheel B, and on its axis is fixed the large ſpur-wheel D, called the *fly-wheel*, giving motion to the two pinions E, F, of the engines K and L: the ſhaft of the wheel D and pinion C are ſupported at one end in a frame H H I, and the other, in a bearing fixed in the wall Q. The engines K and L are placed on the floors N and O upon different levels, as ſhewn by *fig.* 1, the bottom of L being higher than the top of K, ſo that the contents of L may be let down through a plug-hole in the bottom. The upper engine L is called the *waſher*, where the rags are firſt worked coarſely, with a ſtream of water running through them to waſh and open their fibres; after which waſhing they are called *half ſtuff*, and are then let down into the beating engine K, to be ground, and reduced to a finiſhed pulp, proper for moulding into ſheets of paper.

By the arrangement of the wheels of the mill, the cylinders, *k* and *l*, of the two engines are contrived to make about from 120 to 150 revolutions *per* minute, when the water-wheel moves with its proper velocity; though the beating engine revolves much quicker than the waſher, its pinion, F, having only 24 teeth, while the waſher, F, has 28. The great wheel, B, has 196 teeth, and the pinion, C, 38 teeth; therefore it makes about 5½ turns, for one of the water-wheel. The wheel D has likewiſe 196 teeth, and turns the waſher, F, of 28 teeth about 36 times, for once of the water-wheel; and the beater, E, about 42 times. M is a cog-wheel, put in motion by the teeth of the great wheel B: on the extremity of its ſpindle is a crank *a*, which, by a connecting rod, gives a reciprocating motion to a lever *c d*, for the purpoſe of working two pumps, *e*, *f*, which raiſe water into a ciſtern *h*, drawing it from the water of the mill-dam by a ſuction-pipe *g*. Theſe pumps raiſe up a conſtant ſtream of fair water, which is neceſſary to be kept running through the rags in the waſhing-engine, to carry away the dirt ſeparated from them by the operation.

The engines are ſhewn at K and L, in the plan: each conſiſts of a wooden vat or ciſtern, divided by a partition in the middle; and in one of theſe diviſions, their cylinders, *k* and *l*, are ſeen. Theſe are provided with teeth or cutters, which act againſt ſimilar teeth fixed in blocks, ſituated beneath the cylinders, to cut the rags between them. when they revolve. The ſtructure of an engine is more minutely explained by *figs.* 1, 2, 3, 4, &c. of *Plate* II.; *fig.* 1 being a ſection through the length of the engine, and *fig.* 2, a horizontal plan. The large vat or ciſtern, A A, is of an oblong figure on the outſide, the angles being cut off; but the inſide, which is lined with lead, has ſtraight ſides and circular ends. It is divided by a partition B B, alſo covered with lead. The cylinder, C, is fixed faſt upon the ſpindle D, which extends acroſs the engine, and is put in motion, as before deſcribed, by the pinion E, placed on the extremity of it. The cylinder is made of wood, and furniſhed with a number of teeth, or cutters, fixed faſt on its circumference, parallel to the axis, and projecting about an inch, as is ſhewn on a larger ſcale at *fig.* 5. Immediately beneath the cylinder, a block of wood, H, is placed, and provided with ſimilar cutters to thoſe of the cylinder, which, when they revolve, paſs very near the teeth of the block, but do not touch; the diſtance between them being capable of regulation, by elevating or depreſſing the bearings on which the necks, D, D, of the ſpindle are ſupported. Theſe bearings are made on two levers, F, F, which have tenons at their ends, fitted into upright mortiſes, made in ſhort beams, G, G, bolted to the ſides of the engine. (See alſo *fig.* 3.) The levers, F, F, are moveable at one end of each, the other ends being fitted to riſe and fall on bolts, in the beams G, as centres. The front one of theſe levers, or that neareſt to the cylinder C, is capable of being elevated or depreſſed, by turning the handle of the ſcrew *b*, which, as ſhewn in *fig.* 3, acts in a nut *a*, fixed to the tenon of F, and comes up through the top of the beam G, upon which the head of the ſcrew takes its bearing. Two braſſes are let into the middle of the levers, F, F, and form the bearings for the ſpindle of the engine to turn upon. The ſcrew, *b*, is uſed to raiſe or lower the cylinder, and cauſe it to cut finer or coarſer, by enlarging or diminiſhing the ſpace between the cutters in the block and thoſe of the cylinder.

Near K, *figs.* 1 and 2, is a circular breaſting made of boards, and covered with ſheet-lead: it is curved to fit the cylinder very truly, and leaves but very little ſpace between the teeth and breaſting. An inclined plane, K, leads regularly from the bottom of the engine-vat to the top of this breaſting; and at the bottom of it the block, H, is fixed. The engine is ſupplied with water by a pipe, Q, bringing it from the pump: this pipe delivers it into a ſmall ciſtern, M, adjoining, and communicating with the engine. The pipe has a cock, P, to ſtop the entrance of the water, when required, or to regulate the quantity of its diſcharge. The ſmall ciſtern has a grating fixed acroſs it, covered with a hair-ſtrainer, to catch any extraneous matter, which may come in with the water; or a flannel bag is ſometimes tied over the orifice of the cock P, through which all the water muſt be filtered. When the engine is filled with water, and a quantity of rags put in, they are, by the revolution of the cylinder, drawn between its cutters and the teeth of the block H. This cuts them in pieces; then, by the rapid motion of the cylinder, the rags and water are thrown over the top of the breaſting, upon the inclined plane: in a ſhort time, this raiſes more rags and water into that part of the engine-vat; and the tendency to reſtore the equilibrium puts the whole contents of the vat in ſlow motion, down the inclined plane K, and round the partition B B, by which they come to the cylinder again in about the ſpace of 20 minutes; ſo that the rags are repeatedly cut and chopt in every direction, till they are reduced to a pulp.

This circulation is of advantage, in turning the rags over in the engine, and cauſes them to preſent themſelves to the cutters in a different direction every time; for as the cylinder cuts or clips in ſtraight lines, in the ſame manner as a pair of ſhears, it is requiſite to cut the rags acroſs in different directions, to reduce them to a pulp. The manner of the cutting is this: the teeth of the block are placed rather inclined to the axis of the cylinder, as ſhewn by *fig.* 4, but the teeth of the cylinder are parallel to its axis; therefore, the cutting edges, when they meet, are at a ſmall angle, and come in contact firſt at one end, and then ſucceſſively the contacts proceed along to the other end, ſo that any rags interſperſed between them are cut in the ſame manner as they would be between the blades of a pair of ſhears. Sometimes the plates or cutters, *k*, in the block are bent to an angle in the middle, inſtead of being ſtraight, and inclined to the cylinder: in this caſe, they are called elbow plates, and of courſe the two ends are both inclined to the axis of the cylinder in oppoſite directions. In either caſe, the edges of the plate of the block cannot be ſtraight lines, but muſt be curved, to adapt themſelves to the curve which a line traced on the cylinder will of courſe have. The plates or cutters of the block are united, by ſcrewing them altogether, and fitting them into a cavity cut out in the wooden block H; their edges are bevelled away on one ſide only, as ſhewn at *k* in the ſection, *fig.* 4. The block is fixed in its place by being made dovetailed, and truly fitted into the

bottom of the ciftern, fo that the water will not leak by it. The end of it comes through the wood-work of the cheft, and projects a fmall diftance on the outfide of it, being kept up to its place by a wedge, fo that by withdrawing this wedge, the block becomes loofe, and can be removed, to fharpen the cutters, as occafion requires. This is done on a grindftone, the plates being firft feparated from each other.

The cutters of the cylinder are fixed into grooves, cut in the wood of the cylinder, at equal diftances from each other round its circumference, in a direction parallel to its axis: the number of thefe grooves is twenty; and for the wafher, each groove has two cutters or bars put into it; then a fillet of wood is driven faft in between them, to hold them firm; and the fillets are kept faft by fpikes driven into the folid wood of the cylinder. The beater is made in the fame manner, except that each groove contains three bars, and two fillets, as fhewn in *fig.* 5.

In the operation of the cylinder, it is neceffary that it fhould be inclofed in a cafe, or its great velocity would throw all the water and rags out of the engine. This cafe is a wooden box L L, inclofed on all fides except the bottom: one fide of it refts upon the edge of the vat, and the other upon the edge of the partition B B. The lines, *c*, *c*, reprefent the edges of wooden frames, which are covered with hair or wire-cloth; and immediately behind thefe, the box is made with a bottom, and a ledge towards the cylinder, which makes a complete trough. The dark fpaces, *e*, *e*, in *fig.* 1, fhew the fituation of two openings, or fpouts, through the fide of the cafe, which lead to flat lead-pipes, *h*, *h*, *fig.* 2, which are placed by the fide of the vat; the beam, F, being cut away for them. There are wafte pipes, to convey away the foul water from the engine; for the cylinder, as it turns, throws a great quantity of water and rags up againft the fieves: the water goes through them, and runs down into the trough at *e e*, and from thence into the ends of the leaden pipes, *h*, *h*, *fig.* 2, by which it is conveyed away: *d*, *d*, *fig.* 1, are grooves for two boards, which, when put down in their places, cover the hair-fieves, and ftop the water from going through them, if it is required to retain the water in the engine. This is always the cafe in the beating-engines, and therefore they are feldom provided with thefe wafte-pipes, or at moft on one fide only; the other fide of the cover being curved, to conform to the cylinder. Except this, the only difference between the wafhing-engine and the beater is that the teeth of the latter are finer, having 60 inftead of 40 bars on its circumference; and it revolves quicker than the wafher, fo that it will cut and divide thofe particles which pafs through the teeth of the wafher.

In fmall mills, where the fupply of water is limited, they frequently have but one engine, and ufe it both for wafhing and beating, by fetting the fcrew fo as to let the cylinder down and make its teeth cut finer; but the fyftem of all confiderable works is to have two engines, or four, if the fupply of water is fufficiently great. We have feen a very capital paper mill containing five engines, where three of them are beaters and two workers; becaufe the beating takes fo much more time, that when the numbers are equal, the wafhers will often do too much for them, and they will have to ftand ftill. A mill to drive four engines is generally made double, that is, it has two water-wheels, and all the machinery fhewn in the plan; and if either of thefe give motion to three engines, they are arranged rather differently: thus the two beaters are placed on the fame level with each other, and this removes them to a greater diftance afunder than fhewn in *fig.* 1, *Plate* I.; fo that the ends of the two engines, when placed on the fame floor or platform, will juft touch each other. The wafher is then placed on the oppofite fide of the wheel D, *viz.* where the word *plan*, *fig.* 2, is written, its pinion being upon the fummit of the wheel, which raifes it to the proper level: the vat of the wafher has a valve or cock in each end, to let out its contents into either of the beaters at pleafure.

The mills with fpur-wheels, fuch as is given in our drawing, are not very common, though they work much better than the ordinary arrangement of the wheels for a paper mill: in this the fhaft of the water-wheel has a large face, or crown-wheel, fixed upon it, which actuates a wooden trundle fixed upon a vertical fhaft, proceeding upwards through the floor of the mill, and there it carries two large horizontal crown or face-wheels, giving motion to the pinions of the engines, which are fituated on oppofite fides of the upright fhafts. It is neceffary to have two horizontal wheels, becaufe of the different levels at which the engines muft be placed. Thefe mills are generally made in wood, in a very rude and coarfe manner, with crown-wheels and large cogs, fo that the friction is very great. Their only recommendation to the paper-maker is their cheapnefs of erection; but this is only on account of their inferior workmanfhip, for to make a mill in iron with a vertical fhaft and bevelled wheels, as they fhould be to work properly, would be far more expenfive than the conftruction fhewn in *fig.* 1, which is therefore adopted by thofe manufacturers who choofe to have their mills made in a complete and durable manner.

The quantity of water which a paper mill can command to turn its engines, generally limits the extent of its trade; and hence the manufacturers fhould attend to every improvement of the machinery which can increafe their effect. Where the fupply of water is conftant, they work the engines day and night, though the making the paper, as it requires many workmen, is of courfe carried on in the day time only. This fyftem neceffarily requires a large vat to be provided, which is called the *ftuff-cheft*, and is a general receptacle for the pulp, where it is kept till wanted to be made into paper; at the fame time this mixes the pulp of different day's work together, and produces an uniformity in the quality and colour of the paper, which is a great recommendation for printing large editions of books.

A very large and capital paper mill, at Maidftone in Kent, which is the principal feat of the paper trade in England, is worked by fteam-engines, and is found to anfwer very well. The machinery and building of a paper mill fhould be well made, and firmly put together, otherwife its great velocity, and power, produces a tremor, which in time fhakes every thing to pieces. The noife and vibration of a wafhing-engine is moft tremendous; for when it revolves 120 times *per* minute, and has 40 teeth, each of which paffes by 12 or 14 teeth in the block at every revolution, it will make near 60,000 cuts *per* minute, and each of them fufficiently loud to produce the moft horrible growling found which can be conceived. The beater revolving quicker, having 60 teeth, and 20 or 24 cutters in the block, will make 180,000 cuts *per* minute, which is fo rapid, as to produce a coarfe mufical note or humming, which may be heard at a great diftance from the mill. This great number of cuts will account for an engine being able, in the courfe of four or five hours' working, to reduce a quantity of rags to thofe exceedingly minute filaments, of which paper is compofed.

The operation of grinding the rags in the engines requires fome management to produce the beft effect: the operation of the wafhing-engine is to open the rags, and to feparate their fibres from each other, rather than to cut

them, and at the same time, by the stream of water which runs through, to carry off all dirt. At first putting into the washing-engine, they should be worked gently, not to cut, but only to rub the rags violently, that the water may have the best effect in carrying off the impurities: this is done by raising up the cylinder, so that its teeth do not touch the teeth of the block, for if the washer cut and divided the rags too much in the first instance, the water would carry away a considerable portion of the finest parts. The cock is at this time opened to admit a great stream of water. When this has continued 20 or 30 minutes, the bearing of the cylinder is let down so low, that its weight rests upon the teeth of the cutter, and it now begins to cut the rags in pieces, the supply of water is diminished, and the operation is at first very violent, the rags frequently causing the cylinder to leap up a considerable height. After working about three or four hours, the engine will get to work very steadily, because the rags, though not reduced to a pulp, are cut very small, and make less resistance to its motion: at this period the washing is usually concluded, and the contents of the engine, called *half stuff*, discharged into a large basket, which allows the water to draw away. For some kind of paper it is thought advisable to let the half stuff remain four or five days to *mellow*, or indeed ferment; and if fermentation is at all proper, this must certainly be the best stage for it, when all the mass of rags is brought to an equal state of division of the fibres. The bleaching is, as before-mentioned, sometimes performed upon the half stuff, instead of bleaching the rags previously; but more commonly it is done in the washing-engine, and this is the most convenient method of all, as it requires no apparatus, and takes very little time, puts the manufacturer to no other expence than the bleaching salt (muriate of lime) by which it is performed, and the effect, if well managed, is equal to that of bleaching by the oxymuriatic acid gas, as at first described. After the rags have been washed for four hours, as above-mentioned, if it is required to bleach the stuff in the engine, they stop the water from running in at the cock, and throw into the engine a quantity of bleaching salt, or muriate of lime. For fine rags, one or two pounds, more or less, are used, according to the quantity of rags the engine contains, which is usually one hundred weight: the two sliders, *d, d, fig.* 1, *Plate* II., are put down in the cover of the cylinder, to prevent the water getting away. In this state the engine is worked about an hour for the bleaching to take place, and during this time the rags lose their colour; but this does not colour the water, though it is rendered rather white and milky by the salt. The very best rags, when first put into the engine, are of a very yellow and dirty colour; but they become, by the bleaching, a very perfect snow white: the cylinder is usually raised up a very little during the bleaching, which being concluded, the water-cock is opened again, the boards, *c, c*, are removed, and the washing continued about an hour to wash the salt away, which must be done very perfectly, or it will continue to act upon, and injure the quality of, the materials.

The half stuff is next put into the beating-engine, and worked till it becomes a fine pulp, which will generally take four or five hours, water being let into it at proper times, to dilute the pulp to its proper consistence, but no water is let out of the beating-engine as in the washer. The quantity of water requires great judgment, as it has an influence on the quality of the paper; and the kind of water the manufacturer is obliged to employ must be considered. The fairest water is the best for paper-making, on account of the clean and white quality so desirable in the manufacture. The water that dissolves soap best, is also the fittest for taking the grease out of rags. Paper-makers say that the water which is most beaten, and that which comes from afar, makes a better curdled paper, stouter, and of stronger consistence, as to matter: if this is the case, it is probably because this water has had more time for depositing the slime, and other heterogeneous parts, and that, being more exposed to the air by motion, it is thereby in a better condition for dissolving grease and soap. Water, subject to be mudded by rain, and that which runs through marshy grounds, ought to be avoided. In like manner, a paper mill ought not to be placed below other manufactories or machinery, which, by using the same water, might communicate to it a bad quality. The water of ponds, and rain water, are very good for dissolving soap, and may therefore be used for paper, if in a pure state. Water, impregnated with lime, by having run off from chalky soils, is generally very pure and clear to the eye, and is, therefore, much used for paper-making, but it is apt to deposit a slight incrustation upon the brass wire of the moulds, which they remove by occasionally washing them with vinegar.

For printing papers, the sizing is done in the beating-engine, towards the end of its operation, as we shall describe: the size is necessary to prevent the ink from sinking into the paper like blotting-paper; but printing-ink not being so fluid as writing-ink, the paper can be sufficiently sized in substance, without subjecting the sheets to a separate operation after they are made. The size for the engine is composed of alum pounded very fine, and mixed up with a quantity of oil: about a pint and a half of this mixture, thrown into the engine at intervals, during the last half hour of the beating, is sufficient. In order to give that bloom, or blue cast to the paper, which some kinds have, a quantity of powder blue is frequently put into the engine at the same time. The pulp is now run off into the *stuff-chest* where the different kinds are mixed, and it is taken out as it is wanted, in the vats where the dippers, &c. work to form the sheets.

The moulding of the paper should be carried on in a lofty room, well ventilated, and with a smooth and even ceiling, that the steam arising from the several vats of pulp may not be condensed upon it, and fall in drops, for a single drop falling upon a sheet of paper, whilst it is moulding, will beat a hole through it, or at least spoil it. The people in this apartment work at the *vats*, with *moulds*, *deckles*, *felts*, *vat press*, and *wet press*. The *vat* used to contain the pulp is a tub. generally about five feet in diameter, and two and a half in depth. It is provided, on the upper part, with planks enclosed inwards, and even railed in with wood, to prevent any of the stuff from running over in the operation: a plank, pierced with holes at one of the extremities, is placed across the vat, and resting on the planks which surround the vat, forms a support to rest the mould upon, when a sheet of paper has been made, and it remains here a short time to drain off the superfluous water. The stuff in the vat is kept at a proper temperature, by means of a grate introduced at a hole in the side, and surrounded on the inside of the vat with a case of copper. For fuel to this grate charcoal or wood is used, and frequently, to prevent smoke, the wall of the building comes in contact with one part of the vat, so that the fire has no communication with the room where they make the paper. The paper is made into sheets upon the *mould* and *deckle*. The *mould* is a square frame, or shallow box, made of well-seasoned mahogany, and covered at the top with wire-cloth; its dimensions are an inch or an inch and a half larger than the sheet of paper intended to be made upon it. The wire-cloth of the mould is varied in proportion to the fineness of the paper and the nature of the

ftuff. It confifts of a number of parallel wires ftretched acrofs the frame, very near together, and tied faft through holes in the fides; alfo a few other ftronger wires, extending acrofs in a direction at right angles to the former, and a confiderable diftance afunder, the fmall wires being bound down to them by fine wire at the interfections. This may be readily underftood, from the examination of a fheet of fome kind of paper on which the marks of the wires remain, becaufe the paper is thinner in thofe places where the wire touched it.

By a modern improvement, thefe marks, called water-marks, are avoided, and the paper has a fmooth even furface. For this the wire is wove in a loom, exactly like cloth, and ftretched over the frame of the mould. The wire-cloth is in this cafe made larger than the intended fheet of paper, and turned down over the fides of the frame, being fewed faft to it by fine wire, fo that the cloth is ftrained tight over the frame. The wove paper, as it is called, when made on thefe moulds, is a very fuperior article to the old paper, particularly for books, but a prejudice ftill prevails in favour of the old paper with lines, which obliges manufacturers ftill to make it, though by no means fo fine or good as the wove.

The *deckle* is a fquare frame of mahogany, bound with brafs at the angles; it is made very thin, and its outfide correfponds with the fides of the mould, while the infide is the fize of the fheet. This frame is neceffary to retain the ftuff of which the paper is made on the cloth, and it muft be exactly flat, that it may fit upon the wire-cloth of the mould, otherwife the edges of the paper will be ragged and badly finifhed. The deckle, when placed upon the wire of the mould, forms a fhallow fieve or mould, in which a quantity of the pulp is taken up, and by the draining through of the water, the pulp is left in a fheet upon the wire. There is no faftening for the deckle, as it is moveable, and only held upon the mould, by the workman grafping the mould and deckle together in both hands at the oppofite fides. This admits of the deckle being removed, that the fheet of paper may be taken up from the wire, by applying the mould upon a piece of felt. The *felts* are pieces of woollen cloth, fpread over every fheet of paper, and upon which the fheets are *laid*, to detach them from the wire of the mould; they alfo prevent them from adhering together, and imbibing part of the water with which the paper is charged, tranfmit the whole of it when placed under the action of the *vat prefs*. The moulding of the paper is performed by three workmen, the *dipper*, the *coucher*, and the *lifter*. The firft of thefe having filled the vat with pulp, muft be attentive to mix it up well; for this purpofe, he employs two implements, one of which is a fimple pole, and the other a pole armed with a piece of board, rounded and full of holes. This operation is repeated as often as the ftuff falls to the bottom. In the principal mills they ufe for this purpofe what is called a hog, which is a machine within the vat, that, by means of a fmall wheel on the outfide, is made to turn conftantly round, and keep the ftuff in perpetual motion.

When the ftuff and water are perfectly mixed, it is eafy to perceive whether the previous operations have been complete. If the ftuff floats clofe, and in regular flakes, it is a proof that it has been well ground, and the parts of the rags, which have efcaped the cylinder of the engine, alfo appear. The dipper ftands in a nitch, or hollow part of that kind of ledge or table which goes round the circumference of the vat; he holds a mould in both hands, by the two extremities, with the deckle applied exactly over the mould, as if only one piece; then inclining it a little towards him, he dips it into the vat, and brings it up again into a horizontal pofition. The fuperfluous part of the pulp flows over on all fides, and the quantity thought fufficient is fhaken gently, from the right to the left, and up and down horizontally, until it is equally extended over the whole furface of the mould. Thefe two motions are alfo accompanied by a flight fhake, that ferves to fix and ftop the fheet. As the water drains through the wire, the fibrous parts of the ftuff arrange themfelves regularly on the wire-cloth of the mould, not only in proportion as the water efcapes, but alfo as the workman favours this effect, by gently fhaking the mould. This done, the mould is immediately laid on the edge of the vat, the deckle taken off, and the mould made to flide along the board which is laid acrofs the vat, to the part where the fheet is to be laid or taken off. The board, which is but two inches in breadth where the fheet is laid, is nothing more than a deal board, which runs along the length of the vat, and is pierced with feveral holes at the extremity, for letting the mould drain into the vat. The dipper taking the deckle off the firft mould, places it immediately on a fecond, which is given him for dipping in its turn; and the fecond workman, called the coucher, taking the mould off the board that runs acrofs the vat with the left hand, raifes it gently, and lays it in an inclined pofition againft one or two fmall pins, which are driven into the board on the edge of the vat. In this condition the mould remains two or three feconds of time for draining into the vat, whilft the coucher extends a felt, on which he applies the mould to take off the fheet, which being done he returns the mould to the dipper.

They proceed in this manner, laying alternately a fheet and a felt, till they have made fix quires of paper, which is called a poft, and this they do with fuch fwiftnefs, that in many forts of paper two men make upwards of twenty pofts in a day.

When the laft fheet of the poft is covered with the laft felt, all the workmen about the vat unite together, and fubmit the heap to the action of the vat prefs. They begin at firft to prefs it with a middling lever, and afterwards with a lever about fifteen feet in length.

The dipper fhould be attentive, in diftributing the matter on the mould, to reinforce the corner the coucher is to take hold of, in raifing and extending the fheets; for without this precaution he would break a great many. Alfo, if he takes up too much matter with his mould, if he does not equally extend it, or if he ftrikes his mould againft the drainer. In all thefe cafes the matter is accumulated in certain parts of the mould, producing fomething like ridges in the paper, or if he lets the matter reft on the mould, and does not diftribute it immediately, there will be parts of unequal thicknefs. When the vat is too hot, the ftretching out of the fheet will be ill performed, becaufe the water evaporates too foon from the mould. Add to this, that in letting the matter run towards one of the edges, by not giving his arm a regular motion, he may form a feather-edged paper, which may likewife happen if he does not extend his ftuff fufficiently; or if the vat be too hot, or the fecula of the pulp is too crude, and does not run well; if his arms are too ftiff, and if he gives a bad fhake, or if the mould be ill made.

In order to avoid drops of water, which, if they fall upon the paper, will make difagreeable fpots, the mould fhould be raifed readily; and as often as the coucher returns his mould to the drainers, he ought to be careful to fhake his hands behind him; for without this precaution, his fingers, which are wet, would drop upon the fheet already laid, whilft he is covering it with the felt. If he is alfo too quick

in laying, the air detained and compressed under the sheet occasions a bloating, and makes some parts more clear than others.

In consequence of the construction of the mould, it is easy to perceive that the sheets of paper will take, and preserve, the impression of all the wires which compose it, and of the empty spaces between them. This is seen in examining a sheet of paper before the light, a greater opacity being found on both sides of each brass wire, than towards the midst of the space. This thickness is occasioned by the pulp, which the motion of the mould could not distribute, being stopped by the small wires, and still more by the large cross wires. This defect is completely remedied by the improvement of weaving the wire of the mould like cloth. The traces of the old wires are most evidently perceived on the side of the sheet which was attached to the mould, and on the other side they form an assemblage of rounded risings. In the paper which is most highly finished, the regularity of these impressions is still visible; therefore it is evident, that all the operations to which it is submitted, have chiefly in view to soften these impressions without destroying them; it is necessary, therefore, to attend to the combination of labour which operates on these impressions. The coucher, in turning the mould on the felt, flattens a little the rounded eminences, which are in relievo on one of the surfaces, and occasions, at the same time, the hollow places made by the wire-cloth to be partly filled up; meanwhile the effort which is made in detaching the paper, produces an indefinite number of small hairs on every protuberant part of the sheet. Under the action of the press, first with the felts, and then without them, the perfecting of the grain of paper still goes on. The vestiges of the protuberances made by the wires of the mould are altogether flattened, and in consequence the hollows opposite them disappear also, but the traces formed by the interstices of the wire, in consequence of their thickness, appear on both sides, and are rounded by the press.

The grain of the paper is often disfigured by the felts when they are too much used, or when the wool does not cover the thread. In this case, when the paper is submitted to the press, it takes the additional traces of the warp and the woof, and composes a surface extremely irregular.

The two sides of the felt are differently raised, and that on which the hair is longest, is applied to the sheets which are laid down, and any alteration of this disposition would produce a change in the texture of the paper. The stuff of which the felts are made should be sufficiently strong, in order that it may be stretched exactly on the sheets, without falling into folds, and at the same time sufficiently pliant to yield in any direction, without injury to the wet paper. As the felts have to resist the reiterated efforts of the press, it appears necessary that the warp be made strong, of combed wool, and well twisted. On the other hand, as they have to imbibe a certain quantity of water, and to retain it, it is necessary that the woof be of carded wool, and drawn out into a slack thread.

The paper remains in the vat press during the time that the next post of paper is preparing, and when it is removed to make room for that, the business of the third workman, called the lifter, begins; it is to take the sheets off the felt, (for they are caused to adhere to them by the action of the press,) and then making the sheets up into a second pile; but if the coucher works too fast, and the lifter finds himself hard pressed, he cannot stretch out his sheets exactly upon one another, so as to make a neat and compact pile, which is very necessary to make paper of a regular and equal thickness, when put under a second or wet press, which is done as soon as several of the piles are completed, and can be collected together. This second pressure being made with all the sheets in contact with each other, expresses a great quantity of water from the paper, and gives the sheet a very considerable strength; it also tends to take out those freckles on the surface of the sheets, which were occasioned by the impression of the felt, though it is necessary to have felts in the first pressure, because the paper is then so soft and pulpy, that it would be pressed into a solid mass if the sheets touched each other. The paper remains in the second press as long as it can, until another pile is made ready by the lifter. When the paper has undergone these operations, it is not only softened in the surface, but better felted, and rendered more pliant in the interior parts of the stuff. In short, a great part of the water which it had imbibed in the operation of the vat is dissipated. By the felting of paper is understood the approximation of the fibres of the stuff, and their interlacing so as to adhere close together. The paper is felted in proportion as the water escapes, and this effect is produced by the management and reiterated action of the press: without this action the paper would be porous, and composed only of filaments without adhesion. When the sheets are very thin, and it is found, after the second pressure, that they are formed by a fecula, which is still so saturated with a great deal of water, that they have little consistence, it is probable that the second press will join them to one another, and it is difficult to separate them; indeed they cannot well be taken off singly without tearing a great number. This is a proof that the business of the press has been badly conducted. To avoid this inconvenience, it is necessary to bring down the press at first gently, and by degrees with greater force, and to raise it as suddenly as possible. By this means the water, which is impelled to the sides of the heaps which has not yet escaped, returns to the centre, the sheets are equally dried, and the operation is executed without difficulty. The separation, sheet by sheet, is not necessary for drying, so that seven or eight may be taken together, which is called forming the pages; sometimes also a less number may do, when the paper is of a large size, but never less than three sheets are hung up together. It is of more importance than we are aware of, that the sheets should thus remain, as it were, pasted several of them together: if they were single, they could not resist the moisture of the size, yet this moisture is sufficient to facilitate their separation; but to prevent their separating when they are hung up to dry, they should be so placed that the pages may receive the wind in the surface, and not in the sides and edges. When the paper is removed from the second press, it is taken to the drying lofts, which are very extensive apartments, usually the upper parts of all the buildings of the mill: the sides are formed by luffer boards, which are a kind of lattice or boarding which can be opened or shut, to admit more or less air, at pleasure. The sheets are taken up upon a piece of wood like a T, and hung upon hair lines, stretched across large horizontal wooden frames, called *tribbles*, and these, as they are filled, are lifted up between upright posts to the top of the room, and retained by pegs put in the posts; then another frame being filled, is put up in its turn, and so on till the loft is filled from top to bottom.

The principal care in drying the paper, consists in gradually admitting the external air, and in preventing the cords from imbibing moisture; for this reason the lattices or luffer boards should be constructed with great exactness, and the cords may be prevented from imbibing the water by covering them with wax. In using such cords, the moisture does not continue in the line of contact between the paper and the cord, which prevents the sheet from stretching in that particular place by its weight, and from

obtained feveral patents during its progreffive ftages of improvement; but an act of parliament was paffed in 1807, to extend the ufual term of all thefe patents to fifteen years from that period, and they then enrolled a fpecification in the records of Chancery, detailing the machine, in its moft improved ftate, and from this we have taken the following defcription; though it is fcarcely poffible to defcribe fuch a very complicated machine without figures. The pulp having been prepared, in the ufual manner, to due confiftence, by the admixture of water, kept in motion in the vat by means of what are denominated hogs, is let out through feveral circular apertures in front of the vat, which can be narrowed or widened at pleafure, by means of a fliding plate. Thefe apertures admit the pulp into a trough, which has a low fide, or lip, and over the edge of this it flows, in a continued cafcade, or even fheet: this trough of the vat is placed at one end of the machine, fo that the ftream of pulp falls upon a wire-cloth, or web, of many yards in length, the ends of which being united together, it is extended horizontally, in the manner of a jack towel, over two rollers, one of them placed clofe under the lip, or mouth of the vat, fo that the ftream of pulp defcends as little as poffible. The wire is kept fupported by feveral other parallel rollers, that it may not hang down or bag, but be kept as level as poffible, and by a very ingenious contrivance is kept extended in breadth to a proper tenfion; it therefore reprefents a table of feveral yards in length, which, by the revolution of the rollers, is kept in continual motion from the vat towards the end of the machine. The pulp is kept within bounds upon this table, according to the width intended to be given to the paper, by two pieces or rulers of wood, exactly parallel with each other, and alfo with the line of motion of the wire. Between the wire itfelf and thefe rulers are placed two endlefs ftraps of leather, as wide as the rulers, and revolving with the fame velocity as the wire, but over different rollers. Similar rulers, and endlefs ftraps, are alfo placed in contact with the lower furface of the wire, fo that the wire is confined between them on each fide, and the liquid pulp thus prevented from running off on the fides, and they act as deckles to the mould. As they move together, they occafion no friction to deftroy the wire. Near that part of the wire upon which the pulp falls from the lip in the vat, there is placed a flap of oiled filk, or other material, to prevent the pulp from running back towards the vat over the roller of the wire.

As the wire revolves upon its rollers, and carries the pulp along upon its furface from the vat to the other extremity, it is conducted between two rollers, fitted up in the manner of a rolling mill, which caufe a preffure upon the pulp and paper to force out the water, and are therefore called the wet-prefs. In order to guard the pulp, which before paffing between the rollers is in a foft ftate, from being diflodged, or otherwife injured by the upper roller coming immediately in contact with it; a revolving endlefs web of felt is applied. This is made of the fame width as the endlefs wire, but not fo long, and it is extended, like that, upon rollers fituated above the wires; it is likewife brought between the rollers of the wet-prefs, fo that its under furface falls upon the furface of the pulp, or paper, and defends it from the action of the upper cylinder: the wire and the felt are thus brought into contact with the paper between them, and the required preffure is given by means of fcrews, which increafe or diminifh the diftance of the large compreffing rollers, and thefe being covered with flannel cloth, or felting, are prevented from injuring the wire webbing, as well as producing a better effect upon the paper than naked cylinders would do.

To prevent the water thus preffed out of the pulp from running back upon the paper, the wire is not only made to defcend before it paffes the wet-prefs, but there is alfo placed a fmall roller refting upon the wire, as near the prefs as poffible, and fome part of the water is previoufly got rid of, by both the wire and felt, with the pulp between them, paffing through a fmall pair of rollers, to the axis of the upper one of which rollers are hung weights, in order to give a flight preffure. The water that drains from the pulp is collected into a trough, and returned to the vat by means of a fcoop-wheel inftead of a pump, which might form the paper ftuff into lumps or rolls, by the mutual friction or rubbing of any parts of the apparatus againft each other, and the reafon for returning the water into the vat is to prevent the lofs of a confiderable portion of the paper, ftuff, blue, fize, &c. which would otherwife be fuftained by its running to wafte.

It is evident then, that if motion is given in the proper direction to the wet-prefs cylinders, having both the web and wire thus compreffed between them, they will be drawn along by them, and caufed to revolve upon their refpective rollers; and that, as long as thefe webs continue fo to revolve, and the pulp continues fupplied and running upon the furface of the under web, fo long will the machine continue making a fheet of paper, of continually increafing length. But as the paper, even after having paffed between the rollers of the wet-prefs, is not of that confiftency and ftrength as would allow of its being removed from the machine and cut in fheets, the new-made paper is caufed to detach itfelf from the wire, at the moment it comes to the extreme roller, over which the wire revolves, and is immediately received upon a fecond web of felt, which is, like the former, ftretched by two principal rollers and other fubordinate ones. By the revolution of this web, which muft have the fame velocity as the former, the paper is brought between two rollers of brafs or other hard metal, which are turned perfectly fmooth, and placed fome diftance from the wet-prefs cylinders, but exactly parallel to them, and after paffing through them the paper is received and wound upon a reel, or roller, which is from time to time removed, and others applied in their room as they are filled with paper.

This is the general action of the machine, but there are a number of very ingenious movements, which we have not mentioned. The fhaking movement of the mould, which is fo neceffary to make the pulp coagulate into paper, is, in this machine, given to the wire thus: the frame of the roller on which the wire is extended at the end near the vat, is fo placed on the top of upright legs, which are moveable on centres, as to admit the roller and wire with the deckle ftraps to move fideways a fmall quantity, and to return, in the manner of vibration, by the action of a crank. The number of thefe vibrations, or fhakes, neceffary in a given time, and the fpace paffed through by the wire in each, will vary according to the quality and preparation of the pulp. The number, however, feems, by obfervation, to be limited to one or two hundred *per* minute, and the fpace between a quarter of an inch, and an inch. To enable the paper-maker readily to give a proper velocity to the crank according to his judgment, the fame is turned by a fmall independent water-wheel, the velocity of which, and confequent number of vibrations, are regulated, at pleafure, by the quantity of water admitted upon the wheel. The fliding plate in the vat, which admits the pulp to flow out as firft mentioned, is regulated by a fcrew, by which the circular aperture may be opened or fhut in any intermediate degree, fo that the quantity of pulp required to run from the

The excise duties on paper are subject, like other impositions of the same kind, to successive variation, both in their amount and rate; and so are likewise the bounties and drawbacks. And as, in the course of a few years, the enumeration of them would not only be useless, but erroneous, we shall content ourselves with observing, in general, that the principal act by which duties of excise are now collected, is the 43 Geo. III. c. 69; that by the 43 Geo. III. c. 81. more duties were added to those imposed by the former act, and by other subsequent statutes other duties increase the whole amount; and the particulars may be found in the schedules annexed to the several acts. We shall here subjoin some more permanent regulations.

Paper which hath paid the duty may be exported, and also books; and drawbacks are to be allowed subject to the regulations prescribed in several acts. (26 Geo. III. c. 78. 34 Geo. III. c. 20. 43 Geo. III. c. 69. sched. G.) The officer attending the packing of paper for exportation, shall take off the stamps from each ream or bundle, and any person obstructing him in this service shall incur a forfeiture of 50*l.* (26 Geo. III. c. 77.) By 49 Geo. III. c. 98. certain duties of customs are also payable upon papers; but old rags, old ropes or junks, or old fishing nets, may be imported duty free. (11 Geo. I. c. 7.) By 32 Geo. III. c. 54. Officers of the customs shall cause any printed, painted, or stained paper that is imported to be marked; and counterfeiting or forging the mark or number, subjects to a forfeiture of 100*l.*; and counterfeiting or forging any stamp or seal for making the impression, incurs a forfeiture of 500*l.*; and any person who shall sell paper with such counterfeit stamp, knowing the same, shall forfeit 50*l.* By 34 Geo. III. c. 20. the importation of books for sale, first printed in this kingdom, and reprinted in any other, incurs forfeiture of the same, and also 10*l.*, and double the value of such book; provided this shall not extend to any book that has not been printed or reprinted in this kingdom, within twenty years before the same shall be imported, &c.

Every maker of paper or pasteboard, and every paper-stainer, shall take out a license from the office of excise, annually, for which he shall pay 2*l.*, on pain of forfeiting 20*l.* (24 Geo. III. c. 41. 43 Geo. III. c. 69. sched. A.) All brown paper, made of old ropes, or cordage only, without separating or extracting the pitch or tar from them, and without any mixture of other materials, shall be deemed paper of the second class or denomination, and be chargeable with the duty accordingly; and all other paper whatever (glazed paper for clothiers and hot-pressers excepted) shall be deemed to be of the first class or denomination. (42 Geo. III. c. 94.) No paper shall be painted or stained for hangings, except that for which the duty on paper of the first class hath been charged, duly stamped, &c. (41 Geo. III. c. 8.) Nor is the maker to diminish any paper before it be charged, under the penalty of 50*l.* and also such paper. Pasteboard is to be made of paper charged, and unused for any other purpose, on pain of 100*l.*, together with forfeiture of the same, and utensils, &c. employed in making it. (42 Geo. III. c. 94.) By the same act, the maker of pasteboard shall produce to the officers all such paper as he intends to use for pasteboard, duly wrapped and stamped, after 24 hours' previous notice, on pain of 100*l.*: nor shall any maker of pasteboard be a paper-maker, nor manufacture within a quarter of a mile of a paper manufactory, on pain of 100*l.* Places of making or keeping paper, pasteboard, mill-board, scale-board, or glazed paper, all utensils and materials employed, shall be entered, on pain of forfeiture, and also of 50*l.* (34 Geo. III. c. 20.) All paper shall be made up into quires, each quire consisting of 24 sheets, and such quires shall be made up into reams of 20 quires each; and all pasteboard, &c. shall be made up in parcels, each parcel containing even dozens of sheets, of one and the same denomination, and of equal dimensions, and not less than 24, nor more than 72 such sheets in every parcel; tied up, &c. in wrappers, and marked with the class of paper to which it belongs, the number of the reams made by the maker during the current quarter, &c. &c. on penalty of 200*l.* and forfeiture. (42 Geo. III. c. 94.) Every maker may make his paper into quires without folding, provided that such quires, when made up into reams, be separated by a slip of coloured paper placed between each quire, and visible on the outside of the ream, and that the outside quires of each ream consist of not less than 20, nor more than 24 sheets, at the option of the maker. Every maker, whose mill or workhouse is situated in any city or market-town, who shall have any paper, paste-board, &c. to be weighed, and charged with the duty, shall give 24 hours (elsewhere 48 hours) previous notice, in writing, to the officer of excise, who shall attend, and such maker, or his servant, shall produce to the officer all such paper, pasteboard, &c. duly tied up, that the duty may be charged previous to removal; stamps shall be provided by the commissioners of excise; and if any person shall counterfeit such stamps, and sell with such counterfeits, knowingly, he shall forfeit 500*l.* (34 Geo. III c. 20.), but this penalty is repealed, and the person committing the offence is adjudged guilty of felony, and subjected to transportation, as a felon, for seven years. 47 Geo. III. sess. 2. c. 30.

Paper-makers are enjoined to give notice to the proper officers of their names, places of abode, store-houses, &c. and to make regular entries, on oath, every six weeks, of all paper, &c. made by them, on penalty of 50*l.* and the duty shall be paid in six weeks after entry, on pain of double duty. 34 Geo. III. c. 20.

Paper-makers are forbid to remove or to conceal their paper, &c. till the officer has taken account thereof, on penalty of 50*l.*, and forfeiture of the paper, &c. (24 Geo. III. c. 18. 34 Geo. III. c. 20. 42 Geo. III. c. 94.) Nor shall paper, &c. be removed in less than 24 hours, under the same penalty; nevertheless it may be removed from one mill to another, upon giving 48 hours' notice, in writing, to the officer. Paper that has been stamped and charged, is to be kept separate from other paper, and also paper of one class from that of another, on pain of 50*l.*

Persons molesting officers in the execution of this act (34 Geo. III. c. 20.) incur a penalty of 100*l.* and the penalties and forfeitures shall be appropriated, one moiety to the king, and the other moiety to the informer.

There is a drawback of the duties on paper exported; and also for books printed at Oxford or Cambridge, in the Latin, Greek, Oriental or Northern languages, and also for bibles, testaments, psalm-books, or books of common prayer, printed either in those universities, or by the king's printer, under certain conditions. 43 Geo. III. c. 69. sched. C.

Pasteboard, made of paper that hath paid the duty, shall not be charged with farther duty. (34 Geo. III. c. 20. 42 Geo. III. c. 94.) Allowance shall be made on paper damaged, for which the duty hath been paid; upon seven days' notice: and allowance shall be made to clothiers and hot-pressers; on certain conditions. 42 Geo. III. c. 94. 43 Geo. III. c. 69.

Stained paper (besides the duty paid for the paper before staining) is subject, by the former acts, to a duty of $1\frac{1}{4}d.$ a yard square. 43 Geo. III. c. 69.

Papers are of various kinds. With regard to colours,

they may be divided into *white*, *brown*, *blue*, &c. With regard to quality, into *fine*, *second*, *bastard*, *superfine*, &c. With regard to use, into *writing*, *printing*, *pressing*, *cap*, *cartridge*, *copy*, *chancery*, *post*, &c. With regard to dimensions, into *demy*, *medium*, *fool's-cap*, *pot*, *royal*, *super-royal*, *imperial*, *elephant*, *atlas*, &c. With regard to country, into *German*, *Lombard*, *Rochelle*, *Genoa*, *Holland*, &c.

French paper is divided into *large*, *middle*, and *small*. To the small belong those called *petit Romaine*, *petit Raisin*, or *Bâton royal*, *petit nom de Jesus*, and *petit à la main*, all thus denominated from the marks impressed on them in making. Also the *cartier*, for the backs of playing cards; *pot* for the figure side; *couronne*, which has commonly the arms of the comptroller-general of the finances; *telliere*, with the arms of the late chancellor Tellier, and a double T; and *champy*, or *à chassis la serpente*, so called from its mark, the serpent; which being extremely fine and thin, is used by fan-makers.

To the middling sort belong the *grand raisin simple*, *carré simple*, *cavalier*, and *lombart*, the three last of which are for printing; *l'ecu*, or *de compte simple*, *carre double*, *l'ecu double*, *grand raisin double*, and *couronne double*, which three last are denominated *double* on account of their strength and thickness. Add to these the *pantalon*, or paper with the Dutch arms; and grand *cornet*, so denominated from the impression on it.

To the larger belong the *grand Jesus*, *petit et grand fleur-de-lis*, *chapelet*, *colombier*, *grand aigle*, *dauphin*, *soleil*, and *l'étoile*, which are thus called from the figures they bear, being all proper for printing either at the letter-press or rolling-press; also for merchants books, and for drawing on. The *grand monde* is the largest of all. Vide Savar. D. de Comm. tom. ii. p. 965, seq.

We have also *printed paper*, for hanging rooms. (See PAPER-*hangings*.) *Stamped paper*, to write obligations, deeds, and contracts upon. (See STAMP.) *Ruled paper*, for books of accounts, &c. To which may be added *cut paper*, and *gilt paper*, for letters, &c. See GILDING *of Paper*.

PAPER, *Blue*, is a sort used by tradesmen to wrap up goods; as sugar-loaves, pieces of linen, &c.

PAPER, *Blotting*, is paper not sized, and in which therefore ink readily sinks or spreads. It is used in books of account, &c. in lieu of sand, to prevent blotting and disfiguring the opposite pages. The same kind is likewise used by apothecaries in filtrating juices, and other matters, for which the *manica Hippocratis* is not so proper.

PAPER, *Teint*, or *demi-teint*, for designing on, is either *brown*, *blue*, or *bisterd*.

PAPER, *Bisterd*, is white paper washed over with a sponge dipped in soot-water. Its use is to save the labour of the crayon, in places which are to be shadowed the same depth with the teint of this paper. For light places, they are made thereon with white chalk. Vide Corneil. Elem. de la Peint. Prat. cap. 15. p. 35. seq.

PAPER, *Marbled*, is a sort of paper variously stained, or painted as it were with divers colours; made by applying a sheet on the surface of a liquor wherein colours diluted with oil or ox's gall are suspended.

The manner of making it is thus: a trough is provided of the shape and dimensions of a sheet of the paper to be marbled, and about four fingers deep: this is made of lead or wood well joined, and pitched or primed to contain the liquor. For the liquor, a quarter of a pound of gum tragacanth is macerated four or five days in fair water; this they stir from time to time, and add to it daily fresh water, till it be of a consistency somewhat thinner than oil; then they strain it into the trough.

The colours to be applied thereon, for blue, are indigo ground up with white lead, or Prussian blue and verditer may be used: for green, indigo and orpiment, the one ground and the other tempered, mixed and boiled together with common water; or verdigris, a mixture of Dutch pink and Prussian blue, or verditer, in different proportions: for yellow, orpiment bruised and tempered; or Dutch pink and yellow ochre: for red, the finest lake, ground with raspings of Brasil wood, which has been prepared by boiling half a day; or carmine, rose pink, vermilion, and red-lead; the two latter of which should be mixed with rose pink or lake, to bring them to a softer cast: for orange, orange lake, or a mixture of vermilion, or red-lead, with Dutch pink: for purple, rose pink and Prussian blue. Into all these colours, properly ground with spirit of wine, they put a little ox or fish gall, which is two or three days old; and if the colours dilate not of themselves sufficiently, they add more gall: on the contrary, if they spread too much, the gall is over-dosed, and must be corrected by adding more of the colour without gall.

For the operation of marbling, when the gum is well settled in the trough, they extend a sheet of paper, and plunge it very shallow into the liquor, suddenly lifting it out again, in order to stir up, and raise the subsiding gum towards the surface, and for the more universal impregnating of the liquor.

This done, and all the colours ranged in gallipots on the table, where also the trough is placed, they begin by dipping a brush of hog's hair into any colour, commonly the blue first, and sprinkle it on the surface of the liquor: if the colour has been rightly prepared, it will dilate itself duly therein. This done, the red is applied in the like manner, but with another pencil: after this the yellow: lastly the green. For white, it is made by only sprinkling fair water, mixed with ox's gall, over the liquor.

When all the colours are thus floating on the liquor, to give them that agreeable cambletting, which we admire in marble paper, they use a pointed stick; which being applied by drawing it from one side of the trough to the other, with address, stirs up the liquor and fluctuating colours; then with a comb, made of wood, about five inches long, with brass teeth, about two inches in length, and a quarter of an inch distant from each other, taken by the head with both hands, they comb the surface of the liquor in the trough, from one extreme to another, permitting only the teeth to enter: this being performed with a gentle and uniform motion, makes those clouds and undulations on which the beauty of the paper depends.

If it be farther desired to have the colours lie in any other fantastical posture, representing serpents, or the like, it is effected with the pointed stick above-mentioned, by drawing it over what has been already combed; but this must be done with a dextrous hand, and with a shallow dip into the liquor, circling, as if you would draw some flourish, or figured letter.

Lastly, the colours being in this posture, the operator displays and applies on them a sheet of white moistened paper; to do which, artist-like, requires a sleight only to be obtained by practice; because the surfaces of the liquor and the paper are to meet equally in all parts; which done, before the colours have time to soak through, which, unless the paper be very thick, will be in the space of two or three pulses, he lifts up the paper nimbly, and with an even hand; and then, after spreading it a while on a board, hangs it on a line to dry; which, when sufficiently done, they first rub it with a little soap, and then polish it with a marble

ftone, ivory knob, or glafs polifhers; or with a burnifher of jafper or agate.

It muft be obferved, that the fprinkling of the colours is to be renewed, and all the other ceremonies performed with the ftick and comb, at every application of frefh paper, by reafon that every paper takes off all the colour from the liquor. Vide Kirch. de Luce & Umbra, lib. x. par. 2. cap. 4. Merr. Obferv. on Neri de Art. Vitr. cap. 42. p. 312. Hought. Collect. tom. ii. p 419, feq.

Some attempts have been made to enrich the marbling, by mixing gold and filver with the colours; which fucceeded well in many attempts in the French king's library, though the expence has hindered the practice from obtaining. Savar. ubi fupra.

Mr. Boyle tells us, that paper, befides its common ufes, may be made into frames for pictures, fine emboffed work, and other parts of furniture. For this purpofe, a convenient quantity of the beft white fort may be fteeped for two or three days in water, till it becomes very foft; then reducing it by the mortar and hot water into a thin pulp, it is laid on a fieve to draw off its fuperfluous moifture; then putting it into warm water, wherein a confiderable quantity of frefh glue, or common fize, has been diffolved, it may afterwards be put into moulds to acquire the defigned figure; and when taken out may be ftrengthened, as occafion requires, with plafter, or moiftened chalk, and when dry painted or overlaid.

This hint is fince improved into a regular manufacture, under the name of *papier machée*.

Another ufe of paper is to ftop up cracks or fiffures in wooden veffels to hold water; for, in this cafe, it will forcibly dilate, and fill the place in which it is to lodge.

PAPER, *Chinefe*, is of various forts; fome is made of the rinds or barks of trees, efpecially thofe abounding in fap, as the mulberry-tree and elm, but chiefly of the bamboo and cotton-tree; but, in reality, almoft each province has its peculiar paper; that of Se-tchuen is made of hemp; that of Fo-kiang, of foft bamboo; that ufed in the northern provinces, of the bark of the mulberry-tree; that of the province of Che-kiang, of wheat or rice-ftraw; that of the province of Kiang-nang, of the fkin found in the filk-worms balls; in fine, in the province of Hu-quang, the tre-chu, or ko-chu, furnifhes the principal material for paper.

As to PAPERS *made of the barks of trees;* the manner of their preparation may be exemplified in the inftance of that of the bamboo, a tree of the cane or reed kind, being hollow, and divided into joints; but much larger, fmoother, harder, and ftronger, than any other fort of reed.

For this paper, they ordinarily only ufe the fecond coat or fkin of the bark, which is foft and white; this they beat in fair water to a pulp, which they take up in very large moulds or frames, fo that they have fheets ten or twelve feet long, and fometimes more. They are completed by dipping them fheet by fheet in alum-water, which ferves inftead of the fize ufed among us; and not only hinders the paper from too freely imbibing the ink, but gives it that luftre which at firft fight makes it look filvered, or at leaft varnifhed over.

The paper thus made is white, foft, and clofe, without the leaft roughnefs to ftop the motion of the pen, or occafion the rifing of any of its fibres; though being made of the bark of a tree, it cracks more eafily than the European paper: add that it is more apt to take moifture, that the duft fticks to it; and that the worms foon get into it; to prevent which laft inconveniency, they are obliged often to beat their books and expofe them to the fun. Add, that its thinnefs making it liable to be foon worn out, the Chinefe are under a frequent neceffity of renewing their books, by frefh impreffions taken from their blocks. Vide Le Compt. Nouv. Mem. fur Chin. lett. 7. Kuft Bibl. Nov. Libr. an. 1697, p. 67, feq. Lett. Edif. & Cur. tom. xix. p. 479.

But the paper of the bamboo, it is to be obferved, is neither the beft, nor the moft ufed, in China. In the former of thefe refpects, it yields the priority to the paper made of the cotton-fhrub, which is the whiteft and fineft, and at the fame time leaft fubject to the inconveniencies above-mentioned; becaufe it keeps as well, and is as durable, as the European paper.

Dr. Grew thinks we may have plants in England, which contain a down that in all probability would make as fine a paper as that made by the Chinefe, from their cotton-fhrub. By which it appears he miftakenly imagined that the Chinefe paper was made not from the rind of the cotton-fhrub, but from the down or cotton itfelf. Vide Grew Muf. Reg. Soc. par. ii. fect. i. cap. 5. p. 215.

But the paper in moft common ufe in China, is that made of the tree called *chu-ku*, or *ku-chu*, which Du Halde compares, firft, to a mulberry-tree, then to a fig-tree, then to a fycamore tree, and laftly, to increafe the embarraffment, to a ftrawberry-tree By all which, we know no more of it than if he had faid nothing about it.

The method of preparing it for paper, is by firft fcraping off lightly the thin outfide of the tree, which is greenifh: then they take off the inner rind in long thin flips, which they blanch in water, and in the fun; and afterwards prepare them in the fame manner as the bamboo. It muft not be forgot, that in the other trees it is only the inward bark that ferves for making paper; but the bamboo, as well as the cotton-fhrub, have this peculiarity, that not only their bark, but their whole fubftance, may be employed, by means of the following preparations.

Out of a wood of the largeft bamboos, they felect fhoots of a year's growth, which are about the thicknefs of the calf of a man's leg: thefe they ftrip of their firft green rind, and fplit them into ftraight pieces of fix or feven feet long: the pieces thus cleft, they fteep in a pond of muddy water, till they rot and grow foft by the maceration. In a fortnight they take them out, wafh them in clean water, fpread them in a large dry ditch, and cover them with lime for a few days; then they take them out again, and having wafhed them a fecond time, they flip them into fmall filaments, which they expofe in the fun to dry and whiten: they throw them into large coppers, where they are thoroughly boiled: and laftly, reduce them by the ftrokes of large hammers to a thin pafte or pulp.

After this, they take fome fhoots of a plant called *ko-teng*; they foak them four or five days in water, till there come out an unctuous fizy fort of juice; this they mix with the pulp of which the paper is to be made, fomewhat in the fame manner as painters temper their colours; care being taken not to put in too much, nor too little of it; on which the goodnefs of the paper much depends.

When they have mixed the juice of ko-teng with the cleft bamboo, and beaten the whole till it refembles a thick clammy water, they pour it into a large deep refervoir, confifting of four walls, raifed breaft high, and having the fides and bottom fo cemented, that the liquor cannot run out, nor foak in.

This being done, and the workmen placed at the fides of the refervoir, they dip in their moulds, and take up the furface of the liquor, which almoft inftantly becomes paper; the mucilaginous and gluey juice of the ko-teng binding the parts, and rendering the paper compact, foft, and gloffy,

but detached parts, and consequently is unfit for all designs where running work, scrolls, or other more complicated ornaments are introduced; it is extremely confined, with respect to the nature of the designs for which it can be employed; and the print is therefore most generally preferred. The method of laying on the flock by means of a print is this: a wooden print being cut (see PAPER-*hangings*) in such manner, that the part of the design, which is intended for the flock, may project beyond the rest of the surface, the varnish is put on a block covered with leather, or oil-cloth, and the print is then used to lay the varnish on all the parts where the flock is to be fixed. The sheet, thus prepared by the varnished impression, is now to be removed to another block or table; and to be strewed over with flock: which is afterwards to be gently compressed by a board, or some other flat body, to make the varnish take the better hold of it. Then the sheet is to be hung on a frame till the varnish be perfectly dry; at which time the superfluous part of the flock is to be brushed off by a soft camel's-hair brush, and the proper flock will be found to adhere in a very strong manner. When the stencil is used, the same method is to be pursued: the varnish for holding the flock being laid on by that instead of a print; and the flock afterwards strewed upon it, as in the other case.

The usual method of preparing the flock is, by cutting woollen rags, or pieces of cloth, with the hand, by means of a large bill or chopping-knife. But it is much more easily and better done by a machine; which may be worked by a horse-mill, at the same time such mill is employed for cutting diamonds, or any other similar purpose. In such case, the construction of that part of the machine, which is made for the cutting the flock, is this.

A box is made for containing the rags or cloth to be cut; which is open at the top; and of such size, as may best suit the quantity of rags that the force employed can cut. A blade is also to be made, the length of which is to be equal to the breadth of the box; and it should be strong; and must be charged with as great a weight as the force employed can be made to raise with a quick motion. The box being filled with the rags or cloth to be cut, is placed under the blade, and made to move by hitches, after the stroke of the blade is given, just so far as where it is proper the blade should again cut the cloth or rags; while, at the same time, the blade is lifted up, and let fall on the cloth, which it cuts through, till by successive strokes, and the progressive motion of the box under it, the whole quantity of cloth or rags in the box has been cut. The box must then be turned, so that one of the sides may become the front; and the operation must be repeated; by which means the cloth or rags, having been cut both ways, will be reduced to the state in which the matter is called flock; and fit to be employed for the purpose of paper-hangings. The work necessary for conveying from the principal mover in the mill, the motion for thrusting forward the box, and raising the blade, may be easily supplied by any ingenious wheelwright, and need not therefore be particularly described here.

There is a kind of counterfeit flock-paper, which, when well managed, has very much the same effect to the eye as the real: though done with less expence. The manner of making this sort is, by laying a ground of varnish on the paper; and having afterwards printed the design of the flock in varnish, in the same manner as for true; instead of the flock, some pigment, or dry colour, of the same hue with the flock required by the design, but somewhat of a darker shade, being well powdered, is strewed upon the printed varnish, and produces greatly the same appearance. Handmaid to the Arts, vol. ii. p. 458, &c.

PAPER-*hangings* are of several kinds; some of which are made in the representation of stucco-work, for covering ceilings, or the sides of halls, stair-cases, passages, &c. and others in imitation of velvet, damask, brocades, chintzes, or such silks and stuffs as are employed for hanging rooms.

The principal difference in the manufacture lies in the grounds; some of which are laid in varnish, and others in the common vehicles for water colours.

The kind of paper employed for this use is a sort of cartoon, manufactured for the purpose, which must be stamped before it be painted. 1 Geo. stat. 2. c. 36.

The colours proper to be used for painting paper-hangings are all those that can be used in water and varnish. But for common designs done with water only, the following are most proper.

For red, lake, vermilion, rose-pink, and red-ochre: for blue, Prussian blue, verditer, and indigo: for yellow, the yellow-berry wash, Dutch pink, and yellow ochre: for green, verdigris, or a mixture of the blue colours with the yellow colours, particularly with the yellow-berry wash: for orange, vermilion, or red lead, with Dutch pink: for purple, a wash made of logwood, or a mixture of the lake, or rose-pink, with deep coloured Prussian blue, or with indigo: for black, ivory black, and in some nicer cases lamp-black: for white, whiting: and for the heightnings, white-lead.

Where great brightness is required, the lake should be used for the crimson red, and Prussian blue for the blue; but for many purposes, rose-pink used alone for the crimson red, and indigo mixt with whiting for the blue, will answer the purpose with greatly less expence. The lake, rose-pink, Prussian blue, and Dutch pink, intended for this use, should be procured in a moist state.

The colours used in varnish may be the same as those used in water; but for this purpose, those just mentioned should be obtained dry.

As for the vehicles of the colours; when water is used, it must be inspissated with size and gum Arabic or Senegal. When burnish is used, it must be formed of oil of turpentine, and the resins and gums which will dissolve in that menstruum. With respect to the grounds for paper hanging, those that are laid in water are made by mixing whiting with the size above mentioned, and laying it on the paper, with a proper brush, in the most even manner. Nothing more is necessary, when the ground is to be left white; and the paper being hung on a proper frame, till it be dry, is fit to be painted. When coloured grounds are wanted, the same method must be pursued; and the ground of whiting first laid; except that, in paler colours, a second coating may sometimes be spared, by mixing some strong colour with the whiting. But where a greater force of colour is wanted, the pigment or colouring substance must be tempered with the proper vehicle, and then spread over the white coat. The varnish grounds are made much in the same manner, by mixing the proper colour with the varnish, and spreading it on the paper.

There are three methods by which paper-hangings are painted: the first by printing on the colours; the second by using the stencil; and the third by laying them on with a pencil, as in other kinds of painting.

When the colours are laid on by printing, the impression is made by wooden prints; which are cut in such manner, that the figure to be expressed is made to project from the surface, by cutting away all the other part. This, being charged with the colours tempered with their proper vehicle, by letting the print gently down on a block, on which the colour is previously spread, conveys it from thence to the ground of the paper, on which it is made to fall more forcibly by means of its weight, and the effort of the arm of the

person who uses the print. The manner of doing this, when more particularly explained, is thus.

The paper being properly prepared by a ground of whiting, colour, or varnish, is laid on a proper block, on which a piece of leather is strained. The colour, mixed with its proper vehicle, is spread on another piece of leather, or oil cloth, laid on a flat block, somewhat larger than the print; which is done by a boy or man who attends for that purpose; and having the colour by him, in a pot, spreads it with a brush on the block betwixt every stroke and impression the printer makes. The print is previously cut in such manner, correspondently to the design of the painting, that there shall be a projection on the surface answering to every part, where that colour intended to be conveyed by this print is necessary. The printer then takes the print either in his right hand, or, when too heavy to be so managed, in both, and drops it gently on the block, just charged with colour; from whence he again immediately raises it in the most perpendicular direction, and lets it fall in the strongest, though most even manner, he can, on the paper; increasing the force by all the additional velocity he can give the print. When this is done, the sheet printed is immediately taken off the block, and hung up to dry; and another being put in its place, the same operation is repeated, till the whole quantity of paper be printed. It is easy to conclude, that there must be as many separate prints, as there are colours to be printed; and they are to be used successively in the same manner as the first. But where there are more than one, great care must be taken, after the first, to let the print fall exactly in the same part of the paper, as that which went before: otherwise the figure of the design would be brought into irregularity and confusion. In common paper of low price, it is usual, therefore, to print only the outlines, and lay on the rest of the colours by stencilling; which both saves the expence of cutting more prints; and can be practised by common workmen, not requiring the great care and dexterity necessary to the using of prints.

The manner of stencilling the colours is this. The figure, which all the parts of any particular colour make in the design to be painted, is to be cut out, in a piece of thin leather, or oil cloth. These pieces of leather, or oil cloth, are called stencils; and being laid flat on the sheets of paper to be printed, spread on a table or floor, are to be rubbed over with the colour, properly tempered, by means of a large brush. The colour passing over the whole is consequently spread on those parts of the paper where the cloth or leather is cut away, and give the same effect as if laid on by a print. This is nevertheless only practicable, without great care, in parts where there are only detached masses, or spots of colours: for where there are small continued lines, or parts that run one into another, it is difficult to preserve the connection or continuity of the parts of the cloth, or to keep the smaller corners close down to the paper; and therefore, in such cases, prints are preferable. Stencilling is indeed a cheaper method of ridding coarse work than printing; but without such extraordinary attention and trouble, as render it equally difficult with printing, it is far less beautiful and exact in the effect. For the outline of the spots of colour want that sharpness and regularity that are given by prints; besides the frequent extralineations, or deviations from the just figure, which happen by the original misplacing of the stencils, or the shifting the place of them during the operation.

Pencilling is only used in the case of nicer work, such as the better imitations of the India paper. It is performed in the same manner as other paintings in water, or varnish.

It is sometimes used only to fill the outlines already formed by printing; where the price of the colour, or the exactness of the manner in which it is required to be laid on, render the stencilling or printing it less proper: at other times it is used for forming or delineating some parts of the design, where a spirit of freedom and variety, not to be had in printed outlines, are desired to be had in the work.

The manner of proceeding with these several methods is, in common work, to stencil first all parts of the colour in the design, and to give an outline to the whole at last, by printing with brown or black: but where there is any running part of the designs, such as scrolls, or the stems or stalks of creeping plants, or flowers, which are to be printed in any other colour than brown or black, a print must be used for them; though, if they require only brown or black, they may be done by the same print which makes the outlines.

In the finer paper, where several colours are laid on with the prints, the principal colour is begun with; and the rest taken successively; the print for the outline being laid on last. In cases where the pencil is to be used, the outline is nevertheless to be made before the colours are laid on by the pencil, if such outline is to be made at all; because that is the guide to the person who lays on the colour; and confines them to a correctness.

In paper printed with designs in chiaro-scuro, such as the imitation of stucco work, and bas relievos, the order of printing must be, to lay on the ground colour first; afterwards the shades; and lastly the lights: and the same rule of succession must be observed where the colours are pencilled. Handmaid to the Arts, vol. ii. p. 445, &c.

Paper-hangings may be spangled with that kind of talc called isinglass, which being reduced to a gross flaky powder, has a great resemblance to thin silver scales or powder. It is laid on by strewing over the varnish, which forms the ground, before it begins to dry. When it is laid on in a figure, for the representation of embroidery, the figure must be printed in varnish, and the talc strewed upon it, and treated like flock. Smalt may also be used in the same manner as flock or spangles. But hangings of this kind are now little used.

Paper, ruled for the reception of musical characters. Rousseau was the first, we believe, who made this a lexicographical article. Five parallel lines form what musicians call the *staff*; upon which lines in the spaces are disposed all the notes of the time-table and their places in the general scale, regulated by clefs at the beginning of each staff.

All our music for keyed instruments, till the latter end of the seventeenth century, was written on staves of six lines, of which the lowest in the treble clef, and highest in the base, was the middle C of the general scale. See Staff.

Almost all the music paper in Italy is ten-staved, for the convenience of scoring songs with four instrumental parts: as the violino primo, violino secondo, alto viola, voice part, and base. These being linked together by braces, are easily found, not only by the fingers, but by the instrumental performers, by whom they may be accompanied from the score.

The English have paper ruled of all forms and number of staves. In general, for violins, of 12 staves, and for the piano forte, and vocal parts, long quarto, as it is more on a level with the eyes, and conceals the visage of the performers less from the audience.

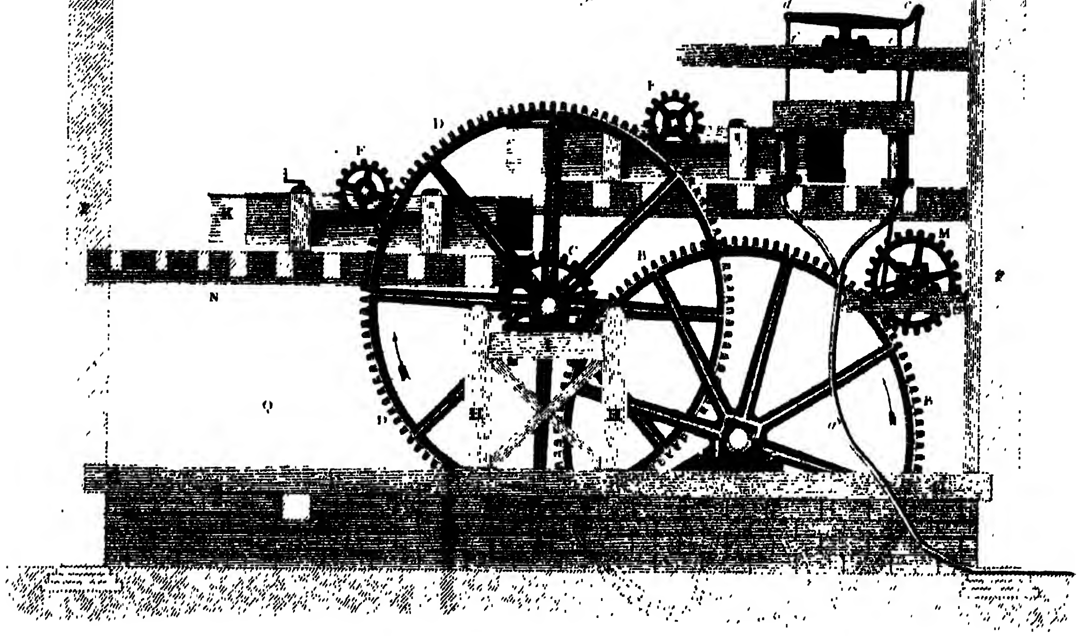
Paper, among *Bankers*, and other negociants, is also used for bills of exchange, bank and promissory notes, &c.

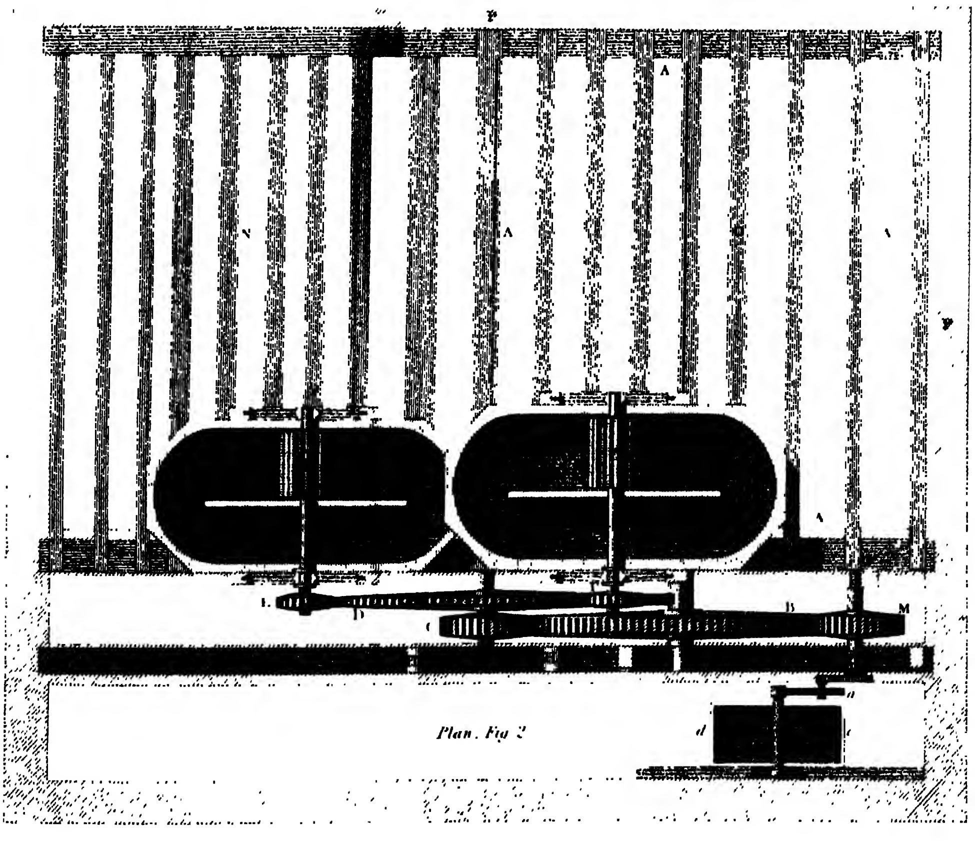
Substituting paper for money, and giving the paper an

arbitrary value, was the way of paying debts introduced in France by Mr. Law. A royal bank was eſtabliſhed, to which people were to carry their money, and receive the value of it in bills, which were to paſs current in trade as ſo much money. (Vide Chevign. Scienc. des Perſ. de la Cour, tom. ii. p. 292.) It was made confiſcation of goods, and the gallies, for any man to keep above forty livres by him of any but paper money. When the regent was told what a rage was ſpirited up againſt him about the arrets of making paper current, and how openly the people threatened him, he anſwered coolly, the French were like watch-dogs, they would bark, but not bite: "Les François reſemblent aux chiens a garde, ils aboyent, mais ne mordent pas." Miſt. Miſc. Lett. tom. iv. p. 16.

PAPER MILL

Elevation Fig. 1





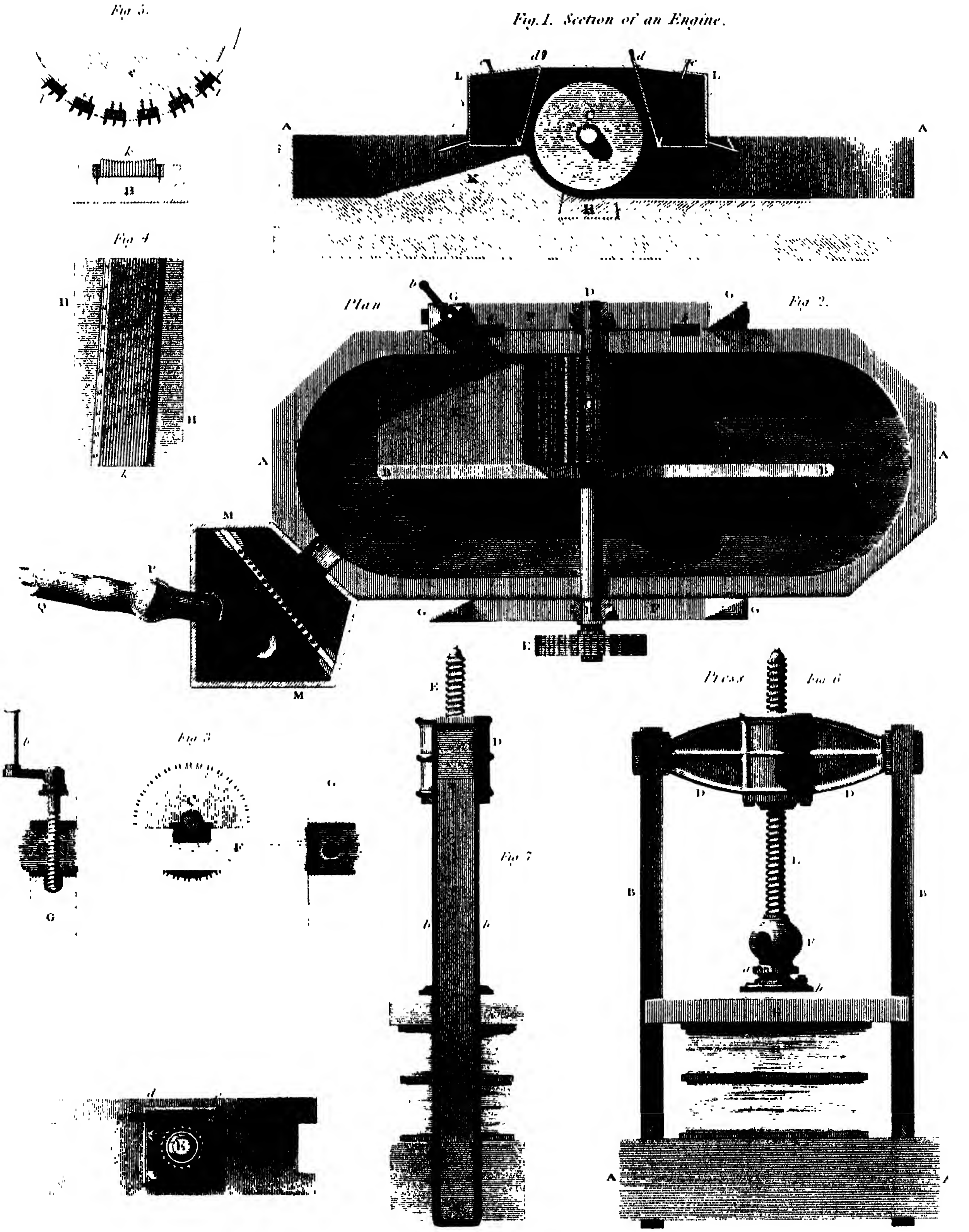
Plan. Fig 2

J. Farey Jun. del

Published as the Act directs 1810 by Longman Hurst, Rees, Orme, & Brown Paternoster Row

PAPER MILL.

PLATE II.



Hurst Rees, Orme & Brown Paternoster Row 1814

Papin

PAPIN, Denys, in *Biography*, an ingenious phyſician, the ſon of Nicholas Papin, alſo a phyſician, was born at Blois. He took the degree of doctor, and travelled to England, where he was elected a fellow of the Royal Society, in December 1680. He paſſed the following year in London, and publiſhed an account of a machine which he had invented, and which ſtill bears his name; this was "The New Digeſter, or Engine for the ſoftening of Bones," 4to. 1681. It ſoon appeared in French, with the title of "La Manière d'Amoliir les Os, et de faire cuire toutes ſortes de Viandes en peu de tems et à peu de fraix." Paris 1682. The machine conſiſts of a very ſtrong metal boiler, with an air-tight cover ſcrewed down with great force; hence the contained matter, being incapable of eſcaping either by evaporation or by burſting the machine, may be heated to a degree far beyond that of boiling water, ſo as to diſſolve the gluten of bones and cartilages. He afterwards improved this digeſter, and it has ſince been much employed in chemical and philoſophical experiments. He aſſiſted Boyle in various experiments, of which an account is given in the hiſtory of the Royal Society. Papin was a Calviniſt, and was therefore prevented from returning home by the revocation of the edict of Nantes. He afterwards reſided at Marpurg, where he taught the mathematics, and publiſhed a "Faſciculus Diſſertationum de quibuſdam Machinis Phyſicis," 12mo. 1696; and in 1707, he publiſhed at Francfort an account of a machine which he had invented for raiſing water by the action of fire, entitled "Ars nova ad aquam ignis adminiculo efficaciſſimè elevandam."

His father, Nicholas Papin, was author of ſeveral works, which, however, are nearly forgotten. Two of them related to the powder of Sympathy, which he defended; and one to the diſcovery of Harvey, which he oppoſed. Eloy Dict. Hiſt. de la Med. Gen. Biog.

Parallel motion

PARALLEL *Motion*, is a term used among practical mechanics to denote the rectilinear motion of a piston-rod, &c. in the direction of its length; and contrivances, by which such alternate rectilinear motions are converted into continuous rotatory ones, or *vice versa;* for pumps, steam-engines, saw-mills, &c. are usually called parallel motions, or parallel levers. In the modern improved steam-engines and pumps, close cylinders are generally used for the pistons to act in, which being worked by polished rods sliding through collars or stuffing-boxes in the lids of the cylinders, it has become necessary to contrive methods for causing the piston-rod to move accurately up and down in the same right line. The different combinations of levers used to produce this effect are worthy of our notice, as exhibiting some ingenious applications of geometrical principles. The object of the parallel motion is, to convert the motion of the end of a reciprocating beam or lever, into a vertical or rectilinear motion; or the continuous motion of a crank at once into a reciprocating motion.

The simplest and most obvious method of producing either of these effects, is to connect the end of the piston-rod to the beam, or the crank, by means of joints, with a connecting rod of a proper length between them, and confine the former, to preserve its rectilinear movement, by sliding through a collar, or in grooves. Friction-wheels may be used to make it work easily; but in machines which have great strains, the constant wear of the grooves or wheels would soon produce looseness, and destroy the parallelism of the motion: recourse must, therefore, be had to parallel levers.

Plate III. of *Steam-engines*, contains three different constructions of levers, which are in common use in steam-engines, to produce parallel motions Two of them, *figs.* 1, 2, 3, and 4, were, we believe, first introduced by Messrs. Boulton and Watt, as appendages to their patent steam-engine, in lieu of the sectors, or arch heads with chains, formerly applied to the beams of the old atmosphere engines. The most simple of these two is represented in *figs.* 3 and 4, where the pump, or piston-rod T, is required to move always in the line T T, when actuated by the beam, or lever, H B, whose centre of motion is A, and the point I, from which the rod receives its motion, of course moves in an arc of a circle. To this point, one end of a bar, or link I K, of any convenient length, is jointed, and to the opposite end, K, the extremity of a lever, K L, is attached by the joint or centre-pin K, the other end, L, moving on a fixed centre of motion. The lever, K L, is exactly equal in length to the acting radius, A I, of the beam, and its centre of motion, L, is attached to a fixed support, so situated, that when the beam, A I, is horizontal, or at right angles to the line T T, the lever, K L, will also be horizontal, and therefore parallel to A I; at the same time the link, I K, which connects them, must hang perpendicular. A centre-pin is fixed at M, exactly in the middle of I K, and to this centre the top of the piston-rod, T, is attached. Now the effect of the combination is, that the point, M, will always move in the vertical line T T, when the beam or the point, I, describes an arc of a circle round the centre A; for it is evident, that when the levers, by the motion of the beam on its centre, are brought into the position shewn by the dotted lines A, I, K, L, (*fig.* 3.) either above or below the horizontal, the upper end of the link, I K, is drawn as much out of the line, T T, on one side, by the curved motion, or sweep of the beam, as the lower end is drawn out of that line, on the opposite side, by the sweep of the lever K L; consequently, its middle point, M, continues always in that line, and prevents the piston-rod deviating from it. The movement may be readily traced by inspection of the diagram, *fig.* 3, which exhibits the levers in three different positions.

Figs. 1 and 2 represent another of Boulton and Watt's parallel motions, and is that now most commonly used by themselves and other engine-makers. This, as before described, has two fixed centres, A and F, and rods connected by moveable joints C, B, D and E, forming a parallelogram.

In setting out of these centres, the line G G, in which the piston is to move, should fall as much short of the end of the beam, or point B, when in the horizontal position, as it will be beyond the end of the same at the two extremes of the movement, which positions are represented by dotted lines, *fig.* 1: the link, B D, connects the end of the beam with the top of the piston-rod, and about half way to the centre of the beam, another link, C E, of the same length, is jointed, being always kept parallel to the former by a connecting rod, D E, which is equal in length to C B, so that C B, D E, may form a parallelogram, in whatever position it may be placed by the motion of the beam, and the consequent motion of the links and coupling-rod on their moveable centres.

The parallelism of the point, D, is produced by means of the lever, E F, which is connected to the point, E, of the parallelogram, and the other end moves on the fixed centre, F; therefore the end, E, of the rod, E D, moves in an arc of a circle, round the centre F; the other end, D, will be found to traverse the right line G G.

The proportions of the levers of this motion admit of great variation: the simplest case is, when the radius, A C, is exactly half of A B, then E F must be equal to A C or C B. Considerable latitude is allowed to the workman in the length of the links B D and C E, without sensibly deranging the parallelism of the point D, and piston-rod attached to it. With these proportions, the centre, F, will fall upon the line G G, which is often inconvenient; for as there are two of the parallelograms, C E and D B, one on each side of the beam, the centres of the lever, E F, cannot be made on one common axis. Eleven different proportions for these levers will appear by the following table of dimensions, in inches, taken from some of the best steam-engines, by various makers in or near the metropolis.

Figs. 1 and 2.	Length of Stroke D d.	Beam A B.	Coupling Rod, D E C B.	Link, C E = B D.	Bridle = Lever E F.
N° 1	96	147	69	42	78
2	72	120	50	28	96
3	72	110	55	31½	55
4	48	90	41	20	60
5	48	84	38	19	60
6	48	84	36	20	54
7	48	72	41	18	25
8	45.6	76	40	28	36
9	36	60	37	12	15.66
10	24	37	16	9	26
11	23	36	16	12	26

The principle on which parallel motion, or what is infenfibly near to one, is produced in all thefe different cafes, will beft appear, after explaining a different conftruction for the fame purpofe by Mr. Freemantle.

Fig. 6. reprefents this parallel motion, which is effected by means of two fixed centres, D and E, and the three moveable ones B, C and A. In this cafe the beam-centre, A, is not ftationary, but has a fmall motion on its fupport D A, which is moveable on the fixed centre D: the centre C, which unites the lever, E C, to the beam, is in the middle of the beam, (*i. e.* B C = C A, and E C is alfo of the fame length,) the fupport, D A, being of any convenient length; but the longer the better, fince the conftruction requires, in ftrictnefs, that the point, A, fhould flide horizontally in the dotted lines E, A, inftead of defcending in each end of its courfe in the arc of tho radius D A. The pifton-rod, G, is jointed immediately to the end of the beam at B. The parallelifm of the motion in this contrivance is effected by the lever, E C, compelling the middle point of the beam, A B, to move upon the arc C C, as it librates upon its centre, whilft that point traverfes upon the top of the bar, A D, to fuch an extent, that the extremity, B, will always traverfe upon the line G G, and of courfe carry the pifton-rod with it. This may be demonftrated thus: fuppofing E A to be a horizontal line, let the dotted line, B A, reprefent any pofition whatever of the beam, and E C the correfponding pofition of the lever; then B C E and A C E will form two ifofceles triangles, becaufe of the equal fides B C and C E, and E C and C A: their oppofite angles are equal, as E B C = B E C, and C E A = C A E; and becaufe the angle, B E A, is made up of the angles B E C and C E A, the fame, (B E A,) is equal to the fum of the two angles, B and A, of the triangle B A E, which fhew the third angle, E, to be a right angle; therefore the point, B, will be perpendicular over E, or perpendicular beneath it, as a fimilar conftruction, below the line E A, would fhew. As the demonftration is equally true of every other part of the movement, as well as its extremes, the angle, B E A, will in all cafes be a right angle, and confequently produce a parallel motion. We have here fuppofed the centre, A, to be confined to flide along the line E A; but in practice it has been found, that the point, A, may be allowed to move in the arc of a circle, defcribed on the centre D, inftead of the right line E A, without producing fenfible deviation in the parallelifm of the point B, and the pifton-rod, G, attached to it. The fixed centre, E, may alfo be moved out of the line B B, either towards or from the centre A, within certain limits, making proportionate alteration in the lengths of the lever E C, and radius A C, as will be evident on making the following comparifon between the conftructions in *fig.* 2. and *fig.* 6. If in *figs.* 1. and 2. we produce the line D E, and from A draw a line parallel to C E and B D, interfecting it in Y, then fuppofe the figures turned upfide down, and end for end, we can compare the fixed centre D, *fig.* 6, with A, *fig.* 2; and the fixed centre E, *fig.* 6, with F; alfo the beam A B, *fig.* 6, with the produced coupling rod Y D; the fupport D A, *fig.* 6, with A Y; and the lever E C, *fig.* 6, with F E: it will then appear that the two conftructions are effentially the fame in principle, fuppofing the fixed centre, E, moved out beyond the line B B, as has been mentioned above to be practicable.

The dimenfions, given in our table above, will fhew what confiderable variations in the proportion of lengths, particularly with regard to the lever E F, *fig.* 2, may be made in practice, without fenfibly impairing this admirable contrivance for producing a vertical motion from a power moving up and down, in the arc of a circle defcribed by the end of the beam.

A very ingenious parallel motion is reprefented in *fig.* 5, which converts the rectilinear motion of a pifton-rod at once to a rotatory motion for a crank or axis. This contrivance has been afcribed to an American, named White; and has been adopted in fteam-engines by Mr. Murray, of Leeds. It is founded on a well-known property of epicycloidal curves, *viz.* that if within any given fixed circle another circle rolls round, which is juft half the diameter of the fixed circle, any point in the circumference of the rolling circle defcribes a right line, which croffes the longer circle, as a diameter thereto. The mode of conftruction is eafily underftood from the figure, in which A B is a fixed circle, or hoop of caft iron, whofe internal diameter is equal to the ftroke of the pifton; it is fupported externally by ftandards G and H, and furnifhed with fmall teeth all round the interior part of its circumference; C is a toothed wheel, whofe diameter is only half that of the ring; the axis of the wheel, which is to have the rotatory motion, paffes through the centre of the ring, and has a circular iron plate, or wheel E, fixed upon the extremity of it; from this plate, a pin or bolt, R, projects, and is by the motion of the axis carried round in a circle, in the manner of a crank. This pin forms the centre-pin of the fmall wheel C, and therefore compels it to roll round within the great circle, and keep the teeth always in contact. The upper extremity of the pifton-rod is attached to a pin, F, fixed on the circumference of the fmall wheel, at the point where the two wheels will be in contact, when at the loweft and higheft points of the motion.

The pin F, at the circumference of the fmall wheel, is adjuftable by a flider and fcrew, fo as exactly to fuit the diameter of the outer circle; and the pifton-rod, being attached to it, is moved truly up and down in the line I K, in a very regular manner, when the axis of the plate, E, is turned round; or *vice verfâ,* if the impelling power is applied to the pifton-rod, in which cafe a fly-wheel muft be applied upon the central axis to regulate the motion.

The extremity of the pifton-rod will be confined to move in the vertical diameter of the ring, becaufe it is made to defcribe an epicycloid of that kind, which is formed by a circle rolling round within the infide of another circle of double diameter, in which cafe, it is well known the epicycloid becomes a diameter of the larger circle, and the fmaller circle makes two complete revolutions, while it is revolving from any one point of the larger circle to the fame point again.

In all the motions we have defcribed, the converfion of the reciprocating motion to a rotative, is effected by means

of a crank, which communicates with the beam by a connecting rod at the oppofite end of the beam, in the manner of H K, *fig*. 4; ufually at the end oppofite to the parallel levers. Some mechanics have fuppofed it defirable, in a parallel motion, to give the pifton-rod, the faw, or the like, an uniform velocity through the whole of its progrefs; then to bring it at once to reft again, and to give it inftantaneoufly its intended velocity in the oppofite direction, and fo on. This the crank will not do, as its motion, at the point where the change or reciprocation of motion takes place, is imperceptible; they have therefore fought other means.

One method of producing this effect is, to make the pifton-rod confift of two parallel bars, having teeth in the fide, which front each other. Let a toothed wheel be placed between them, having only the half of its circumference furnifhed with teeth. It is evident, without any further defcription, that if this wheel be turned uniformly round its axis, the pifton-rod will be moved uniformly up and down without intermiffion. This has often been put in practice, and the pifton-rod made to work between grooved rollers, but the machine always went by jolts and feldom lafted a few days. Unfkilful mechanics attributed this to defects in the execution, but the fault is effential, and lies in the principle. The machine could not perform a fingle ftroke without breaking, if the firft mover did not flacken a little, or the different parts of the machine did not yield by bending, or by compreffion, and no ftrength of materials could withftand the violence of the ftrains at every reciprocation of the motion. This is chiefly experienced in great works, which are put in motion by a water-wheel, or fome other equal power, exerted on the mafs of matter of which the machine confifts. The water-wheel, being of great weight, moves with confiderable fteadinefs, or uniformity; and when an additional refiftance is oppofed to it by the beginning of a new ftroke of the pifton, its great quantity of motion is but little affected by this addition, and it proceeds with very little lofs of motion. The machine muft either yield a little by bending, and compreffion, or go to pieces, which is the common event. Cranks are free from this inconvenience, becaufe they accelerate the pifton gradually, and bring it gradually to reft, while the water-wheel moves round with almoft perfect uniformity. The only inconvenience attending this flow motion of a pifton at the beginning of its ftroke, is, that the valves do not fhut with rapidity, fo that fome water gets back through them. But when they are properly formed and loaded, this is but trifling.

Parchment

PARCHMENT, in *Commerce*, &c. ſheep or goats' ſkin prepared after a peculiar manner, which renders it proper for ſeveral uſes; particularly for writing on, and for the covering of books, &c.

The word comes from the Latin *Pergamena*, the ancient name of this manufacture; which it is ſaid to have taken from the city of Pergamos, to Eumenes, king whereof, its invention is uſually aſcribed; though, in reality, that prince appears rather to have been the improver than the inventor of parchment; for the Perſians of old, according to Diodorus, wrote all their records on ſkins; and the ancient Ionians, as we are told by Herodotus, made uſe of ſheep-ſkins and goat-ſkins in writing, many ages before Eumenes's time. Nor need we doubt, that ſuch ſkins were prepared and dreſſed for that purpoſe, after a manner not unlike that of our parchment, though, probably, not ſo artificially. Vide Diod. Sicul. lib. ii. p. 84. Herodot. lib. v. Prid. Conneƈt. part i. lib. vii. p. 708.

Dr. Prideaux is a ſtrenuous advocate for the antiquity of parchment; and he imagines that the authentic copy of the law which Hilkiah found in the Temple, and ſent to king Joſiah, was formed of this material; becauſe no other uſed for writing, parchment excepted, could be of ſo durable a nature as to laſt from the time of Moſes till that period, for eight hundred and thirty years. But it has been replied to this argument, that the Egyptians wrote on linen thoſe things which they deſigned for long duration; and thoſe who have examined mummies with attention, aſſure us, that the charaƈters ſo written continue to this day. It is not, therefore, improbable, that a copy of the law of Moſes, written after this manner, might have laſted eight hundred and thirty years. Beſides, it is not very likely that thoſe ſkins which were uſed, according to the teſtimony of Diodorus and Herodotus, by the Perſians and Romans for writing, long before the time of Eumenes, were dreſſed like parchment. They muſt have been prepared in a much ruder manner, and have little reſembled the parchment, of which Eumenes is ſaid to be the inventor; becauſe, if it had been found out before, it would have rendered the want of the Egyptian papyrus no inconvenience to that prince. Such ſkins might do for records, and for ſome occaſional writings, but would have been by no means proper for books. Hence ſome writers have concluded, that parchment was a later invention than the Egyptian paper.

Parchment conſtitutes a very conſiderable article in the French commerce; it is made in moſt of their cities; and, beſides the conſumption at home, they ſend vaſt quantities abroad, particularly to England, Flanders, Holland, Spain, and Portugal.

That called *virgin* parchment is ſomewhat thinner and finer than the reſt; and is moſt proper for certain purpoſes, as fans, &c. and made of the ſkin of an abortive lamb, or kid.

PARCHMENT, *Manufaƈture of.* The ſkin having been ſtript of its wool, and having paſſed the lime-pit (after the manner deſcribed under the article SHAMMY), the ſkinner ſtretches it on a kind of frame, conſiſting of four pieces of wood, mortiſed into each other at the four angles, and perforated lengthways from diſtance to diſtance, with holes furniſhed with wooden pins, that may be turned at pleaſure, like thoſe of a violin.

To ſtretch the ſkin on this frame, they make little holes all around it, and through every two holes draw a little ſkewer; to this ſkewer they tie a ſmall piece of pack-thread, and tie that over the pins; ſo that coming to turn the pins equally the ſkin is ſtrained tight every way, like that of a drum.

The ſkin being thus ſufficiently ſtretched on the frame, the fleſh is pared off with a ſharp inſtrument for that purpoſe; this done, it is moiſtened with a rag; and a kind of white ſtone, or chalk, reduced to a fine duſt, is ſtrewed over it: then, with a large pumice-ſtone, flat at bottom, much after the manner of a mullet for grinding colours, they rub over the ſkin as if about to grind the chalk; and thus they ſcour off the remains of the fleſh. Then they go over it again with the iron inſtrument; again moiſten it as before, and again rub it with the pumice-ſtone without any chalk underneath; this ſmoothens and ſoftens the fleſh-ſide very conſiderably. They then drain it again, by paſſing over it the iron inſtrument as before.

The fleſh-ſide being thus drained, they paſs the iron on the wool or hair-ſide; then ſtretch it tight on the frame by means of the pins, and go over the fleſh-ſide again with the iron; this finiſhes its draining; and the more the ſkin is drained, the whiter it always becomes.

They now throw on more chalk, ſweeping it over with a piece of lamb-ſkin that has the wool on; this ſmoothens it ſtill farther, and gives it a white down or knap. It is now left to dry, and when dried it is taken off the frame, by cutting it all round.

The ſkin, thus far prepared by the ſkinner, is taken out of his hands by the parchment-maker, who firſt ſcrapes or pares it dry on the ſummer with an iron inſtrument like that above-mentioned, only finer and ſharper; with this, worked with the arm from top to bottom of the ſkin, he takes away about one-half of its thickneſs. The ſkin, thus equally pared on both ſides, they paſs the pumice-ſtone over both ſides, to ſmoothen it. This laſt preparation is performed on a kind of form or bench covered with a ſack ſtuffed with flocks, and it leaves the parchment in a condition for writing on.

The paring of the ſkin dry on the ſummer is the moſt difficult preparation in the whole proceſs of parchment-making; for which reaſon, the ſkinners ſeldom dare meddle

with it, but ufually leave it to thofe more experienced in it; the fummer, whereon it is performed, is a calf-fkin well-ftretched on a frame, ferving as a fupport to the fkin, which is faftened a-top of it with a wooden inftrument, that has a notch cut in it. Laftly, that the iron knife may pafs the eafier between the fummer and the fkin to be pared, they put another fkin, which they call the counter-fummer. The parings, thus taken off the fkin, are ufed in making glue, fize, &c.

What we call *vellum*, is only parchment made of the fkins of abortive calves, or, at leaft, of fucking calves; it is finer, whiter, and fmoother, than the common parchment; but it is prepared in the fame manner as that, except that it is not paffed through the lime-pit.

PARCHMENT, *To make a green tranfparent.* Wafh the parchment in cold ley, till it come clear from it; then fqueeze out the liquor as much as poffible; and if you would have it of a fine green colour, take diftilled verdigris, ground with vinegar, and add a little fap-green to it; temper it neither too thick nor too thin; then foak your parchment in this colour thoroughly a whole night; rinfe it afterwards in water, ftrain it immediately on a frame, and fet it to dry; take clear varnifh, lay it on both fides, fet it in the fun to dry; after this cut the parchment out of the frame into leaves, as large as you pleafe, and lay them in a book under prefs, to keep them fine and ftraight. The effect of this parchment is to make a fmall letter, when put over it, appear as big again; and it is a great preferver of the eyes, efpecially to thofe that read much by candle-light. The varnifh muft be prepared of linfeed-oil, and boiled with frankincenfe, maftich, and fandarac.

If you would have the parchment of a clear, tranfparent, and white colour, only wafh, ftrain, and varnifh it, as above. If you would colour it yellow, fteep your parchment, after it has been wafhed, in a yellow liquid, made of faffron; for which purpofe, tie faffron in a thin linen rag, hang it in a weak ley, and warm it over a flow fire; and when you fee the ley tinctured yellow, it is fit for ufe.

For a tranfparent red.—Take brazil, as much as you will; put it into a hot ley, which is clear, and not too ftrong, and it will tincture the ley of a fine red; then pour to it about half an egg-fhell full of clean wine; draw the parchment through the colour; and when it is as deep as you would have it, ftrain it as before.

For a blue.—Take Lombard indigo, grind it with vinegar on a ftone, and mix fal ammoniac among it, to the quantity of a pea; with this wet your parchment, and proceed as has been directed for the green.

For a violet or purple Colour.—Temper two-thirds of the above red, and one-third of the blue, and ufe it as before directed.

For a black Colour.—Take Roman alum, beat it into powder, and boil it in rain-water to a fourth part; add Roman vitriol, or atrament, with fome Roman galls, and boil them together: with this ftain your parchment twice or three times over; and, when dry, lay the Spanifh varnifh over it.

N. B. With thefe tranfparent parchments you may make curious bindings. One fort, ufed at Rome, is made thus: lay the board or pafteboard over with leaf-gold, leaf-filver, ftanial, metal-leaves, &c. then binding the parchment over it, it will give it an uncommon luftre and beauty.

Dr. Lewis informs us, that, in order to render the ink durable on parchment, a thick piece of it fhould be fteeped in water, with fome oak-bark, for three or four days, and then preffed fmooth and dried. When the furface of this parchment was pared off, and the internal part written upon, the characters continued of a good black, while thofe made with the fame ink, on unprepared parchment, were changed into a yellowifh-brown. Velium may alfo be treated in the fame manner.

It is faid, that writing upon parchments decayed by time, may be recovered, and rendered legible, by dipping the obliterated parchment into a veffel of cold water, frefh drawn from the well; let it be taken out in about a minute, and preffed between two papers, in order to prevent its crumpling up in drying. As foon as it is moderately dry, if it be not legible, repeat the operation two or three times.

PARCHMENT, *Roll of.* See ROLL.

Parting

PARTING, in the art of refining metals, is a procefs by which gold is feparated from filver. When thofe metals which are oxydable in the cupel have been feparated from gold, the filver not undergoing that change remains alloyed with it. This is always the cafe in refining jewellers' gold. In order to feparate the filver, the alloy is firft rolled into very thin plates, the thinner the better; thefe plates are to be boiled with pure nitric acid. By this means, the filver is diffolved by the nitric acid, giving to the plates a corroded appearance, as if perforated with a fmall inftrument. When the filver ceafes to be diffolved, the plates are to be melted. If the gold is required of greater purity, it may be rolled in plates, and expofed to the acid a fecond time. If the nitric acid contains any muriatic acid, which is generally the cafe with the acid of commerce, fome of the gold will always be diffolved. Should this be the cafe, the filver fhould firft be precipitated in the form of muriat, with common falt, and the gold afterwards thrown down with green fulphat of iron.

The moft effectual method of feparating gold from filver is to diffolve the whole of the thin plates in nitro-muriatic acid. The filver will be found at the bottom of the veffel in the form of muriat, while the gold remains in folution, and may be precipitated with fulphat of iron. The filver may be obtained by heating the muriat with foda in a crucible. The muriat of foda fublimes, while the filver is left pure. See ASSAYING.

PARTING, *Dry*, or parting by fufion, is performed by fulphur, which has the property of uniting eafily with filver, while it does not attack gold. The moft advantageous method, fays Dr. Lewis, of feparating a fmall portion of gold from a large one of filver, appears to be by means of fulphur, which unites with and fcorifies the filver without affecting the gold: but as fulphurated filver does not flow thin enough to fuffer the fmall particles of gold diffufed through it to re-unite and fettle at the bottom, fome addition is neceffary for collecting and carrying them down.

In order to the commixture with the fulphur, fifty or fixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a fmall crucible made red-hot, and pouring it into cold water ftirred

with a rapid circular motion. From an eighth to a fifth of the granulated metal, according as it is richer or poorer in gold, is reserved; and the rest well mingled with an eighth of powdered sulphur. The grains enveloped with the sulphur are again put into the crucible, and the fire kept gentle for some time, that the silver, before it melts, may be thoroughly penetrated by the sulphur; if the fire was hastily urged, great part of the sulphur would be dissipated without acting upon the metal.

If to sulphurated silver in fusion pure silver be added, the latter falls to the bottom, and forms there a distinct fluid, not miscible with the other. The particles of gold, having no affinity with the sulphurated silver, join themselves to the pure silver, wherever they come in contact with it, and are thus transferred from the former into the latter, more or less perfectly according as the pure silver was more or less thoroughly diffused through the mixed. It is for this use that a part of the granulated metal was reserved. The sulphurated mass being brought into perfect fusion, and kept melted for near an hour in a close covered crucible, one-third of the reserved grains is thrown in; and as soon as this is melted, the whole is well stirred, that the fresh silver may be distributed through the mixed, to collect the gold from it. The stirring is performed with a wooden rod; an iron one would be corroded by the sulphur, so as to deprive the mixed of its due quantity of sulphur, and likewise render the subsequent purification of the silver more troublesome. The fusion being continued an hour longer, another third of the unsulphurated grains is added, and an hour after this the remainder; after which the fusion is farther continued for some time, the matter being stirred at least every half hour from the beginning to the end, and the crucible kept closely covered in the intervals.

The sulphurated silver appears in fusion of a dark brown colour: after it has been kept melted for a certain time, a part of the sulphur having escaped from the top, the surface becomes white, and some bright drops of silver, about the size of peas, are perceived on it. When this happens, which is commonly in about three hours after the last addition of the reserved grains, sooner or later, according as the crucible has been more or less closely covered, and the matter more or less stirred, the fire must be immediately discontinued; for otherwise more and more of the silver, thus losing its sulphur, would subside and mingle with the part at the bottom in which the gold is collected. The whole is poured out into an iron mortar greased and duly heated; or if the quantity is too large to be safely lifted at once, a part is first laded out from the top with a small crucible, and the rest poured into the mortar. The gold, diffused at first through the whole mass, is now found collected into a part of it at the bottom, amounting only to about as much as was reserved unsulphurated. This part may be separated from the sulphurated silver above it by a chissel and hammer; or more perfectly, the surface of the lower mass being generally rugged and unequal, by placing the whole mass with its bottom upwards in a crucible: the sulphurated part quickly melts, leaving unmelted that which contains the gold, which may thus be completely separated from the other. The sulphurated silver is essayed, by keeping a portion of it in fusion in an open crucible, till the sulphur is dissipated; and then dissolving it in aqua fortis. If it should still be found to contain any gold, it is to be melted again; as much more unsulphurated silver is to be added as was employed in each of the former injections, and the fusion continued about an hour and a half.

The gold thus collected into a part of the silver may be farther concentrated into a smaller part, by granulating the mass and separating the whole process. The operation may be again and again repeated, till so much of the silver is separated, that the remainder may be parted by aqua fortis without too much expence.

The foregoing process, according to Mr. Schlutter, is practised at Rammelsberg, in the Lower Hartz. The prevailing metal in the ore of Rammelsberg is lead: the quantity of lead is at most forty pounds in a quintal or hundred pounds of the ore. The lead worked off on a test or concave hearth yields about a hundred and ten grains of silver, and the silver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting scarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above mentioned confines this method of separation to such silver as is poor in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a sixty-fourth of the silver: he advises also not to attempt concentrating the gold too far, as a portion of it will always be taken up again by the silver. Mr. Scheffer, however, relates (in the Swedish Memoirs for the year 1752), that he has by this method brought the gold to perfect fineness; and that he has likewise collected all the gold which the silver contained; the silver of the last operations, which had taken up a portion of the gold, being reserved to be worked over again with a fresh quantity of gold-holding silver. The sulphurated silver is purified by continuing it in fusion for some time with a large surface exposed to the air; the sulphur gradually exhales, and leaves the silver entire. Lewis's Comp. Phil. Techn. p. 161, &c. See Gold and Refining.

PARTING-*Glasses* are used in the operation of parting: they have the form of truncated cones, the bottom being commonly about seven inches wide, the aperture about one or two inches wide, and the height about twelve inches. These glass vessels ought to have been well annealed, and chosen free from flaws; as one of the chief inconveniences attending the operation is, that the glasses are apt to crack by exposure to cold, and even when touched by the hand. Some operators secure their glasses by a coating. For this purpose they spread a mixture of quick lime slaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the vessel, leaving the upper part uncovered, that they may see the progress of the operation; and over this cloth they apply a composition of clay and hair. Schlutter advises to put the parting-glasses in copper vessels containing some water, and supported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminished by adding cold water, which must be done very carefully by pouring against the sides of the pan, to prevent too sudden an application of cold to the parting-glass. The intention of this contrivance is, that the contents of the glasses, if these should break, may be received by the copper vessel. Into a glass fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he usually put about eighty ounces of metal, with twice as much aqua fortis.

Pastes

PASTES, in the *Glass Trade,* a sort of composition of the glass kind, made from calcined crystal, lead, and metallic preparations, to imitate the several natural gems. These are no way inferior to the native stones, when carefully made and well polished, in brightness and transparence, but want their hardness.

The general rules to be observed in making them are these: 1. That all the vessels in which they are made are firmly luted, and the lute left to dry before they are put into the fire. 2. That such vessels are chosen for the work as will bear the fire well. 3. That the powders be prepared on a porphyry stone, not in a metal mortar, which would communicate a tinge to them. 4. That the just proportion in the quantities of the several ingredients be nicely observed. 5. That the materials be all well mixed; and if not sufficiently baked the first time, to be committed to the fire again, without breaking the pot; for, if this be not observed, they will be full of blisters and air-bladders. 6. That a small vacuity be always left at the top of the pot, to give room to the swelling of the ingredients.

To make a paste of extreme hardness, and capable of all

the colours of the gems, with great lustre and beauty, take of prepared crystal ten pounds; salt of polverine, six pounds; sulphur of lead, two pounds: mix all these well together, into a fine powder; make the whole, with common water, into a hard paste; and make of this paste small cakes, of about three ounces weight each, with a hole in them, made in their middle: dry these in the sun, and afterwards calcine them in the straightest part of a potter's furnace; after this powder them, and levigate them into a perfect fineness on a porphyry, and set this powder in pots in a glass furnace to purify for three days; then cast the whole into water, and afterwards return it into the furnace, where let it stand fifteen days; in which time all foulness and blisters will disappear, and the paste will greatly resemble the natural jewels. To give this the colour of the emerald, add to it brass thrice calcined; for a sea-green, brass simply calcined to redness; for a sapphire, add zaffer, with manganese; and for a topaz, manganese and tartar. All the gems are thus imitated in paste, by the same way of working as the making of the coloured glasses; and this is so hard, that they very much approach to the natural gems.

The colours in all the counterfeit gems, made of the several pastes, may be made deeper or lighter, according to the works for which the stones are designed; and it is a necessary general rule, that small stones for rings, &c. require a deeper colour, and large ones a paler. Besides the colours made from manganese, verdigris, and zaffer, which are the ingredients commonly used, there are other very fine ones, which care and skill may prepare: very fine red may be made from gold, and one not much inferior to that from iron; a very fine green from brass or copper, and a sky-colour from silver; and a much finer one from the common small garnets of Bohemia, which are of little value. The gems also afford glorious colours like their own.

The fine blue from silver is, probably, only from the small quantity of copper used in the alloy.

A very singular and excellent way of making the paste to imitate the coloured gems is this: take a quantity of saccharum saturni, or sugar of lead, made with vinegar in the common way; set it in sand, in a glass body well luted from the neck downwards; leave the mouth of the glass open, and continue the fire twenty-four hours; then take out the salt, and if it be not red, but yellowish, powder it fine, and return it into the vessel, and keep it in the sand-heat twenty-four hours more, till it becomes as red as cinnabar. The fire must not be made so strong as to melt it, for then all the process is spoiled. Pour distilled vinegar on this calcined salt, and separate the solution from the dregs: let the decanted liquor stand six days in an earthen vessel, to give time for the finer sediment to subside: filter this liquor, and evaporate it in a glass body, and there will remain a most pure salt of lead; dry this well, then dissolve it in fair water; let the solution stand six days in a glazed pan; let it subside, then filter the clear solution, and evaporate it to a yet more pure white and sweet salt; repeat this operation three times; put the now perfectly pure salt into a glass vessel, set it in a sand-heat for several days, and it will be calcined to a fine impalpable powder, of a lively red. This is called the sulphur of lead. Neri's Art of Glass.

Take all the ingredients as in the common composition of the pastes of the several colours, only instead of red lead, use this powder, and the produce will well reward the trouble of the operation, as experience has often proved.

A paste proper for receiving colours may be readily made by well pounding and mixing six pounds of white sand, cleansed, three pounds of red lead, two pounds of purified pearl-ashes, and one pound of nitre. A softer paste may be made, in the same manner, of six pounds of white sand cleansed; red lead, and purified pearl-ashes, of each three pounds; one pound of nitre, half a pound of borax, and three ounces of arsenic. For common use, a pound of common salt may be substituted for the borax. This glass will be very soft, and will not bear much wear, if employed for rings, buckles, or such imitations of stones, as are exposed to much rubbing; but for ear-rings, ornaments worn on the breast, and those little used, it may last a considerable time.

In order to give paste different colours, the process is as follows.

Paste *resembling amethyst.*—Take ten pounds of either of the compositions described under *Colouring of* Glass; one ounce and a half of manganese, and one dram of zaffer; powder and fuse them together. See Amethyst.

Paste *perfectly black.*—Take ten pounds of either of the compositions just referred to, one ounce of zaffer, six drams of manganese, and five drams of iron, highly calcined; and proceed as before.

Paste, *Blue.*—Take of the same composition ten pounds; of zaffer, six drams; and of manganese, two drams; and proceed as with the foregoing.

Paste *resembling the chrysolite*—Take of either of the compositions for paste above described, prepared without saltpetre, ten pounds, and of calcined iron five drams; and pursue the same process as with the rest. See Chrysolite.

Paste *resembling the red cornelian.*—Take of the compositions mentioned under *Colouring of* Glass, two pounds; of glass of antimony, one pound; of the calcined vitriol, called scarlet ochre, two ounces; and of manganese, one dram. Fuse the glass of antimony and manganese with the composition; then powder them, and mix them with the other, by grinding them together, and fuse them with a gentle heat.

Paste *resembling white cornelian.*—Take of the composition just referred to, two pounds; and of yellow ochre, well washed, two drams; and of calcined bones, one ounce. Mix them and fuse them with a gentle heat.

Paste *resembling the diamond.*—Take of the white sand, six pounds; of red lead, four pounds; of pearl-ashes, purified, three pounds; of nitre, two pounds; of arsenic, five ounces; and of manganese one scruple. Powder and fuse them.

Paste *resembling the eagle-marine.*—Take ten pounds of the composition under Glass; three ounces of copper, highly calcined with sulphur; and one scruple of zaffer. Proceed as before.

Paste *like emerald.*—Take of the same composition with the last, nine pounds; three ounces of copper, precipitated from aquafortis, and two drams of precipitated iron. See Emerald.

Paste *like garnet.*—Take two pounds of the composition under Glass; two pounds of the glass of antimony, and two drams of manganese. For vinegar garnet, take of the composition for paste, described in this article, two pounds; one pound of glass of antimony, and half an ounce of iron, highly calcined; mix the iron with the uncoloured paste, and fuse them; then add the glass of antimony, powdered, and continue them in the heat till the whole is incorporated. See Granite.

Paste, *gold,* or *full yellow colour.*—Take of the composition for paste ten pounds, and one ounce and a half of iron strongly calcined; proceeding as with the others.

Paste, *deep purple.*—Take of either of the compositions for paste ten pounds; of manganese, one ounce; and of zaffer, half an ounce.

Paste, *resembling ruby*.—Take one pound of either of the compositions for paste, and two drams of *calx cassii*, or precipitation of gold by tin; powder the paste, and grind the calx of gold with it in a glass, flint, or agate mortar, and then fuse them together. A cheaper ruby paste may be made with half a pound of either of the above compositions, half a pound of glass of antimony, and one dram and a half of the calx of gold; proceeding as before.

Paste *resembling sapphire*.—Take of the composition for paste, ten pounds; of zaffer, three drams and one scruple; and of the calx cassii one dram. Powder and fuse them. Or the same may be done, by mixing with the paste one-eighth of its weight of smalt. See Sapphire.

Paste *like topaz*.—Take of the composition under Glass ten pounds, omitting the salt-petre; and an equal quantity of the gold-coloured hard glass. Powder and fuse them. See Topaz.

Paste *like turquoise*.—Take of the composition for *blue* paste, already described, ten pounds; of calcined bone, horn, or ivory, half a pound. Powder and fuse them.

Paste, *opaque white*.—Take of the composition for paste, ten pounds; and one pound of calcined horn, ivory, or bone; and proceed as before.

Paste, *semi-transparent white, like opal*. See Opal.

Patents

PATENTS, or *Letters* PATENT, in *Law*, the king's letters, sealed with the great seal, serving to convey the title or property of some grant, favour, privilege of a new establishment, or the like. See LETTERS *Patent*.

They have their name from their being delivered open, *ut pateant omnibus*; by way of contradistinction from *letters de cachet*, or *literæ clausæ*, or *close rolls*, which are sealed.

Grants or letters patent must first pass by bill; which is prepared by the attorney or solicitor general, in consequence of a warrant from the crown; and is then signed, that is, superscribed at the top, with the king's own sign manual, and sealed with his privy signet, which is always in the custody of the principal secretary of state; and then sometimes it immediately passes under the great seal, in which case the patent is subscribed in these words, "per ipsum regem; by the king himself." Otherwise the course is to carry an extract of the bill to the keeper of the privy seal, who makes out a writ or warrant thereupon to the chancery; so that the sign manual is the warrant to the privy seal, and the privy seal is the warrant to the great seal: and in this last case the patent is subscribed, "per breve de privato sigillo, by writ of privy seal"

It is to be noted, that patents differ from writs: a coroner is made by *writ*, not by patent.

To this office, enacted 18 Jac. I. belongs a clerk, &c.

PATENT, *Letters*, under the royal authority, confer on a person the exclusive privilege of making and selling any thing, so that no person be restrained in what he had before, or in using his lawful trade. The latter part of the definition of letters patent, or of a monopoly conferred by letters patent, will apply only to such as have been granted since the statute of the 21st of James, c. 2, commonly called the statute of Monopolies; prior to that period, letters patent conferred such a monopoly as interfered with the rights of other people, and restricted the freedom of trade.

Monopoly, in the latter acceptation of the word, has already been considered under its proper head: it existed in this kingdom unrestrained till the time of king John, who first granted municipal franchises. In the 25th year of the reign of Edward III. a statute was passed, which granted a free trade equally to foreigners and natives; this statute, however, was afterwards repealed; and monopolies that not only excluded foreigners from the advantages of English trade, but also injured the English nation at large; in order that the favourites of monarchs might be rewarded, or that the crown might be enriched, were established. During the reign of queen Elizabeth, they had spread so widely over the commercial transactions of the country, as to threaten the utter ruin of trade; when a list of only part of the commodities, which had been appropriated to monopolists, was read in the house of commons, a member cried, "Is not bread in the number?" "Bread," said every one with astonishment; "yes, I assure you," replied he, "if affairs go on at this rate, we shall have bread reduced to a monopoly before next parliament." At this period, most extraordinary powers were granted to the patentees; especially to those who held the exclusive privilege of selling saltpetre; they had the power of entering every house, and of committing what havoc they pleased in stables, cellars, or wheresoever they suspected saltpetre might be gathered. Hume.

It might have been supposed, that such a sagacious princess as Elizabeth would have perceived the evil consequences of granting monopolies; but either the reduced state of the royal funds, or her fondness for favourites, blinded her to the true interests of her people. Towards the end of her reign, however, the clamour of the country was so loud and general, that she sent a message to parliament, that she would immediately cancel the most oppressive of the exclusive privileges she had granted.

Before proceeding to the consideration of the statute of James I. already alluded to, it may be proper very briefly to take a view of the statute law, as it respects patents prior to that period. Monopolies are expressly contrary to Magna Charta, (29, 30.) The statute of Edward III. declared all grants by monopolies void; and when Philip and Mary granted by letters patent, to the mayor, bailiffs, and burgesses of Southampton, the exclusive privilege of importing Malmsey wine at that place, the judges were unanimous in their opinion, that the statute was void, as being against the freedom of trade. The principal statutes relating to patents in the 16th, and in the beginning of the 17th century, were in the 6th of Henry VIII., the 4th of Edward VI., and the 13th and 43d of Elizabeth.

The 21st of James I. ch. 3, is regarded as the declaration statute, by which the law on this subject is determined, and the 6th section of this statute particularly relates to patents for new inventions: this section contains the exception to the general law of the statute; the general law is, that all monopolies, and all commissions, grants, licences, letters patent, &c. for the sole buying, selling, making, using, &c. of any thing, shall be void; the excepting clause declares, that the law of the statute shall not extend to any letters patent, for the term of 14 years or under, granted to the true and first inventor, or inventors of manufactures, &c. which others, at the time of making such letters patent, shall not use. Sir Edward Coke, in his explication of this statute, gives it as his opinion, that the new manufacture, to which letters patent may be granted, must not be generally inconvenient; and this construction seems to have been adopted in his time, as he says, that a patent for a fulling-mill to thicken bonnets and caps, was set aside, on the ground, that it was holden inconvenient to turn labouring men to idleness. But this construction does not prevail now, and, indeed, if it did, it would effectually defeat the object of the sixth section of the statute of monopolies.

In the letters patent which are granted for new inventions, the improvements or inventions are first stated; the prayer of the petitioner to have the exclusive benefit for himself, or his assigns, for fourteen years, is next given; and this prayer is declared to be complied with, according to the statute. After commanding all subjects not to interfere with the patent right, and issuing a mandate to all officers not to molest the patentee in the exercise of it, the letters patent declare the patent void, if it appear that the grant is contrary to law, or prejudicial to the subject; or if the thing invented have been in use before the date of the grant; or if the patentee be not the inventor; or if it interfere with prior letters patent; or if the patent be transferred to more than five persons, or to any who act as a corporate body; or finally, if the nature of the invention be not described, or the description be not enrolled within one calendar month after the date of the letters patent. The letters patent conclude with a declaration, that they shall be construed in the most beneficial sense for the patentee.

A writ of *scire facias*, to repeal letters patent, lies in three cases; 1st, when the king grants the same thing to two or more persons; 2dly, when the king is deceived in his grant; and 3dly, when the grant is against law. The following rules are laid down by chief justice Lee, respecting the cases in which mistakes do not vitiate the grant: 1. If the king's intention is manifest, a false recital in a thing not material, will not vitiate the grant. 2. It is not vitiated in cases where the king is deceived, not by the false suggestion of the party, but by his own mistake, upon the surmise and information of the party. And 3. Although the king is mistaken in point of law, or matter of fact, if that is not part of the consideration of the grant, it will not vitiate it.

Patents for new inventions are granted for a term of fourteen years; and any royal grant for such purpose beyond that term is void. The fourteen years are accounted to commence from the date of the first letters patent. The patent right, however, may be extended by act of parliament.

A patent may be granted for an improvement on an old manufacture; but the improvement must be material and useful; and the patent extends to the improvement only. The statute considers a manufacture brought from abroad into the kingdom (provided it has not been practised before) as a new manufacture, and entitled to letters patent. No old manufacture in use before, can be prohibited by the grant of the sole use of a new invention; nor can a patent be granted for a method, or principle; its object must be some substantial thing produced.

The following rules are laid down by judge Butler, respecting the description required in the specification, which by the patent grant, the patentee is to cause to be enrolled in the high court of chancery. The invention or improvement must be disclosed, and described in such a manner, that others of the same trade may be taught to do the same thing for which the patent is granted: 2. He must describe it in such a manner, that the public, after the expiration of the term, may have the use of the invention in as cheap and beneficial way as the patentee himself; and therefore, if the specification describes many parts of a machine, &c., and the patentee uses only a few of them, or does not state how they are to be put together, the patent is void. 3. If the specification be in any part materially false or defective, the patent is against law, and cannot be supported.

The enrolment of the specification in the high court of chancery, where it is open to the inspection of every one, enables those who are inclined to purchase the machine, invention, &c., to become acquainted with its nature and merits; and, at the same time, prevents such as are employing their skill, time, and money on improvements, or inventions of a similar nature, from merely doing what has been done before.

With respect to the form of the specification, it must be under the hand and seal of the inventor; the enrolment must take place within one calendar month after the date of the letters patent; if the patentee passes over this time, it cannot be enlarged without an act of parliament for that express purpose.

When a patentee brings an action against any person for infringing his patent, it is incumbent on him to shew, that the invention was new, and that the specification is full and complete.

It is frequently for the convenience or interest of a person, who has invented or improved a machine, &c. to delay taking out a patent for it; in this case, he may enter a *caveat*. A *caveat* will protect his invention or improvement for the space of one year, after which, if he have not brought his contrivance to maturity, he may renew it again for an equal period, and so on for any successive number of years. The caveat must be delivered at the chambers of the attorney and solicitor-general; and if an application be made for a patent for an invention of the same nature, notice is given to the person who has entered the caveat: if he requires it, the attorney-general gives a separate audience to each of the rival inventors, and makes his report to the king, according to his opinion respecting the priority of invention. A petition to the king, stating the nature of the invention, and praying letters patent, accompanied by an oath taken before a master in chancery, that the invention is new, are the steps preparatory to taking out a patent. Separate patents must be taken out for England, Scotland, and Ireland; but in a patent for England, the patentee may, on the payment of a small additional sum, have the colonies and plantations abroad included. The petition and oath are referred by the secretary of state for the home department to the attorney-general, and on his report, recommending letters patent, his majesty issues his warrant, in consequence of which the bill is made out, which is the grant of his majesty, and of this the patent is the transcript; the nature of the specification, and the enrolment of it, have been already noticed.

Having thus considered letters patent in a legal light, we shall conclude with a few remarks on them, as a subject of political economy. It is plain from what we have stated, that they are the remains of that system of monopoly, which formerly prevailed in this and all the other countries of Europe; and so far, at first sight, they may appear objectionable. But when we consider the object for which they are granted, we shall probably be of opinion, that it takes them completely out of the force of those objections, which are so justly brought against all monopolies.

It is evident; that no man will bestow his time, ingenuity, and money, in endeavouring to invent or improve any thing, unless, when he has succeeded, he is secure in being rewarded. This reward can be secured to him, only by granting him, for a certain number of years, the exclusive privilege of his invention or improvement; or by government purchasing it from him. In the former case, while his patent right last, he has a monopoly; he may put what prices on his invention he pleases; or he may execute it in a careless or improper manner; but, on the other hand, the public will in a great measure be protected from too high a price, by the alternative they have, of following the old methods; and if they gain by purchasing the new invention, the price put upon it by the inventor can hardly be

ſaid to be exorbitant. With reſpect to his doing his work in a careleſs manner, the public are equally guarded againſt this; for by ſuch conduct, he would act againſt his own intereſt, and the ſale of his invention.

If, indeed, we could ſuppoſe that government would examine, in all caſes, thoroughly, impartially, and ſcientifically, into the merits of every invention, it might be better for them to throw it open to the public, by rewarding the inventor, though in this caſe, the nation at large would pay for what directly and materially benefited only certain claſſes, whereas, by letters patent, thoſe reward the inventor, whoſe intereſt it is to reward him. On the whole, therefore, the preſent mode is the beſt, with perhaps this alteration, that the letters patent ſhould vary in their duration, according to the importance of the invention, and the money and time expended by the inventor.

Pavement

PAVEMENT, a layer or ſtratum of ſtone, or other matter, ſerving to cover and ſtrengthen the ground of divers places, for the more commodious walking on, or for the paſſage of carriages.

The word is formed from the Latin *pavimentum*, of *pavire*, to beat down the earth, in order to make it firm and ſtrong.

In England, the pavements of the grand ſtreets, &c. are uſually of flint or rubble-ſtone; courts, ſtables, kitchens, halls, churches, &c. are paved with tiles, bricks, flags, or fire-ſtone; ſometimes with a kind of free-ſtone, and rag ſtone.

In ſome cities, *e. gr* of Venice, the ſtreets, &c. are paved with brick; churches ſometimes are paved with marble, and ſometimes with moſaic work, as the church of St. Mark, at Venice. In France, the public roads, ſtreets, courts, &c. are paved with gres or grit, a kind of free-ſtone.

In Amſterdam, and the chief cities of Holland, they call their brick pavement the *burgher-maſter's* pavement, to diſtinguiſh it from the ſtone or flint pavement, which uſually takes up the middle of the ſtreet, and which ſerves for carriages; the brick which borders it being deſtined for the paſſage of people on foot.

Pavements of free-ſtone, flint, and flags, in ſtreets, &c. are laid dry, *i. e.* in a bed of ſand; thoſe of courts, ſtables, ground-rooms, &c. are laid in a mortar of lime and ſand; or in lime and cement, eſpecially if there be vaults or cellars underneath. Some maſons, after laying a floor dry, eſpecially of brick, ſpread a thin mortar over it; ſweeping it backwards and forwards to fill up the joints. The ſeveral kinds of pavement are as various as the materials of which they are compoſed, and whence they derive the name by which they are diſtinguiſhed: as, 1. *Pebble-paving*, which is done with ſtones collected from the ſea-beach, moſtly brought from the iſlands of Guernſey and Jerſey; they are very durable, indeed the moſt ſo of any ſtone uſed for this purpoſe. They are uſed of various ſizes, but thoſe which are from ſix to nine inches deep, are eſteemed the moſt ſerviceable. When they are about three inches deep they are denominated bolders, or bowlers; theſe are uſed for paving court-yards, and other places not accuſtomed to receive carriages with heavy weights; when laid in geometrical figures they have a very pleaſing appearance.

2. *Rag paving* was formerly much uſed in London, but is very inferior to the pebbles; it is dug in the vicinity of Maidſtone, in Kent, from whence it has the name of Kentiſh ragſtone; there are ſquared ſtones of this material for paving coach-tracks and footways.

3. *Purbeck pitchens;* ſquared ſtones uſed in footways; they are brought from the iſland of Purbeck, and alſo frequently uſed in court-yards; they are in general from ſix to ten inches ſquare, and about five inches deep.

4. *Squared paving*, for diſtinction by ſome called *Scotch paving*, becauſe the firſt of the kind paved in the manner that has been and continues to be paved, came from Scotland; the firſt was a clear cloſe ſtone, called blue wynn, which is now diſuſed, becauſe it has been found inferior to others ſince introduced in the order they are hereafter placed.

5. *Granite*, a hard material, brought alſo from Scotland, of a reddiſh colour, very ſuperior to the blue wynn quarry.

6. *Guernſey*, which is the beſt, and now almoſt the only ſtone in uſe; it is the ſame ſtone with the pebble before ſpoken of, but broken with iron hammers, and ſquared to any dimenſions required of a priſmoidical figure, ſet with its ſmalleſt baſe downwards. The whole of the foregoing paving ſhould be bedded and paved in ſmall gravel.

7. *Purbeck paving*, for footways, is in general got in large furfaces, about two inches and a half thick; the blue fort is the hardeft and the beft of this kind of paving.

8. *Yorkfhire paving*, is an exceeding good material for the fame purpofe, and is got of almoft any dimenfions of the fame thicknefs of the Purbeck; this ftone will not admit the wet to pafs through it, nor is it affected by the froft.

9. *Ryegate*, or *fire ftone paving*, is ufed for hearths, ftoves, ovens, and fuch places as are liable to great heat, which does not affect this ftone, if kept dry.

10. *Newcaftle flags*, are ftones about two feet fquare, and one and a half, or two inches thick; they anfwer very well for paving out-offices; they are fomewhat like the Yorkfhire.

11. *Portland paving*, with ftone from the ifland of Portland; this is fometimes ornamented with black marble dots.

12. *Swedland paving*, is a black flate dug in Leicefterfhire, and looks well for paving halls, or in parti-coloured paving.

13. *Marble paving*, is moftly variegated with different marbles, fometimes inlaid in mofaic.

14. *Flat brick paving*, done with brick laid in fand, mortar, or groute, as when liquid lime is poured into the joints.

15. *Brick on edge paving*, done with brick laid edgeways in the fame manner.

16. Bricks are alfo laid flat or edgeways in herringbone.

17. Bricks are alfo fometimes fet endways in fand, mortar, or groute.

18. Paving is alfo performed with paving bricks.

19. With ten-inch tiles.

20. With foot-tiles.

21. With clinkers for ftables and out-offices.

22. With the bones of animals, for gardens, &c. And

23. We have knob-paving, with large gravel-ftones for porticoes, garden-feats, &c.

Pavers' work is done by the fquare yard: and the content is found by multiplying the length by the breadth.

Pavements of churches, &c. frequently confift of ftones of feveral colours; chiefly black and white, and of feveral forms, but chiefly fquare, and lozenges, artfully difpofed. Indeed, there needs no great variety of colours to make a furprifing diverfity of figures and arrangements. M. Truchet, in the Memoirs of the French Academy, has fhewn by the rules of combination, that two fquare ftones, divided diagonally into two colours, may be joined together chequerwife fixty-four different ways: which appears furprizing enough; fince two letters, or figures, can only be combined two ways.

The reafon is, that letters only change their fituation with regard to the firft and fecond; the top and bottom remaining the fame: but in the arrangement of thefe ftones, each admits of four feveral fituations, in each of which the other fquare may be changed fixteen times, which gives fixty-four combinations.

Indeed, from a farther examination of thefe fixty-four combinations, he found there were only thirty-two different figures; each figure being repeated twice in the fame fituation, though in a different combination; fo that the two only differed from each other by the tranfpofition of the dark and light parts.

The paving of ftreets is one of the moft beneficial regulations of police that have been tranfmitted to us from our anceftors. Several cities had paved ftreets before the commencement of the Chriftian era; neverthelefs thofe which are at prefent the ornament of Europe, Rome excepted, were deftitute of this great advantage till almoft the 12th or 13th century. It is probable that thofe people who firft carried on the greateft trade, were the firft who paid attention to have good ftreets and highways, in order to facilitate that intercourfe which is fo neceffary to keep up the fpirit of commerce. Accordingly we are told by Ifidorus (Origin. l. xv. c. 16.) that the Carthaginians had the firft paved ftreets, and that their example was foon copied by the Romans. Long before that period, however, Semiramis paved highways, as appears by the vain-glorious infcription which fhe herfelf caufed to be put up. (Strabo, l. xvi. Diod. Sicul. l. ii. v. 13. Polyæni Stratagem. l. viii. c. 26.) The ftreets of Thebes, and probably thofe of Jerufalem, were paved. But neither the ftreets of Rome, nor the roads around it, were paved during the time of its kings. In the year 188, after the abolition of the monarchical form of government, Appius Claudius, being then cenfor, conftructed the firft real highway, called after him the Appian way, and on account of its excellence, the queen of roads. The time when the ftreets were firft paved cannot be precifely afcertained; fome have referred this improvement to the year 578, after the building of the city; others to 584; and others to 459; at which feveral periods fome parts of the city and fuburbs might have been paved. That ftreets paved with lava, having deep ruts made by the wheels of carriages, and raifed banks on each fide, for the accommodation of foot-paffengers, were found both at Herculaneum and Pompeii, is well known.

Of modern cities, the oldeft pavement is commonly afcribed to that of Paris; but it is certain that Cordova in Spain was paved fo early as the middle of the 9th century, or about the year 850. The capital of France was not paved in the 12th century, but the orders for this purpofe were iffued by the government in the year 1184, on which occafion it is faid that the name of Lutetia, deduced from its dirtinefs, was changed into that of Paris. Neverthelefs, in the year 1641, the ftreets in many quarters of Paris were not paved. That the ftreets of London were not paved at the end of the 11th century, is afferted by all hiftorians. It does not appear when paving was firft introduced; but it was gradually extended as trade and opulence increafed. Several of the principal ftreets, fuch as Holborn, which are at prefent in the middle of the city, were paved for the firft time by royal command in the year 1417; others were paved under Henry VIII., fome in the fuburbs in 1544, others in 1571 and 1605, and the great market of Smithfield, in 1614.

Pavement *of Terrace*, is that which ferves for covering in manner of a platform; whether it be over a vault or a wooden floor.

Thofe over vaults are ufually ftones fquared, and bedded in lead. Thofe on wood, called by the Latins *pavimenta contignata*, are either ftones with beds for bridges, tiles for cieling of rooms, or lays of mortar made of cement and lime, with flints or bricks laid flat: as is ftill practifed by the eaftern and fouthern people a-top of their houfes.

All thofe pavements which lie open were called by the Latins *pavimenta fubdialia*.

Pearl-ash

PEARL-*Ash*, in *Chemistry*, *Arts*, and *Manufactures*. The crude potash, when first obtained by the combustion of vegetable matter, abounds with a great variety of impurities, consisting of neutral salts, sulphur, charcoal, and some earthy matter.

When this substance is washed with clean water, and the insoluble matter allowed to subside, the clear liquor is evaporated in large shallow iron pans. The residuum consists of potash properly so called, still containing some neutral salts, but free from its other impurities. It is a mass of a white colour, from which it is called pearl-ash. In this state it is used by bleachers, glass-makers, dyers, and others. The real potash it contains, for which it is valued, is combined with carbonic acid in the proportion of 19 of acid to 42 potash. The remainder consists of sulphat and muriat of potash. See CARBONAT *of Potash*.

The goodness of pearl-ashes must be distinguished by the uniform and white appearance of them: they are subject, however, to a common adulteration, not easily distinguishable by the appearance, which is done by the addition of common salt. In order to discover this fraud, take a small quantity of the suspected salt, and after it has been softened by lying in the air, put it over the fire in a shovel: if it contains any common salt, a crackling and kind of slight explosion will take place, as the salt grows hot.

The pearl-ashes are much used in the manufacture of glass, and require no preparation; except where very great transparency is required, as in the case of looking-glass, and the best window-glass. For this purpose dissolve them in four times their weight of boiling water: when they are dissolved, let the solution be put into a clean tub, and suffered to remain there twenty-four hours, or longer. Let the clear part of the fluid be then decanted off from the sediment, and put back into the iron pot in which the solution was made: in this let the water be evaporated away till the salts be left perfectly dry again. Keep those that are not designed for immediate use in stone jars, well secured from moisture and air.

To those who buy large quantities of this article, it may not be unuseful to know the means of assaying it. Weigh 100 grains of it before it has been exposed to the air; then lay out a known weight of sulphuric acid, of the specific gravity of 1.8, or such as boils at the temperature of 460°. Dissolve the pearl-ash in its own weight of distilled water. With a small sucking tube add sulphuric acid by a small portion at once, till no more effervescence takes place. The weight of the remainder of the sulphuric acid will shew how much has been added to the solution. Then for every grain of sulphuric acid of the above strength taken up, allow .82 of a grain of pure potash. Thus, if 100 grains of the pearl-ash take up 40 grains of sulphuric acid, of the specific gravity 1.8, the pure potash contained in the 100 will be 32.8 grains. See POTASH.

PEARL-*Barley*. (See BARLEY.) This affords, to a microscopic observer, a peculiar kind of mite worthy of attention, and very different from the common species. The bodies of these have some brown marks upon them, and have not such long hairs as the common mites have; the hinder part of the body also is of a different make. They have eight legs; and before the head there stand two weapons twice as thick as the legs, and of about half their length: these are divided towards their ends with joints like fingers, and those have at their ends a sort of nails formed with sharp and crooked claws; and one of the longest joints is serrated at the edge like a saw. These weapons serve not only as arms and hands to seize hold of things, but they also serve as a defence; for as soon as any danger threatens the creature's head, it erects them both, and makes them meet and fold into one another over the head, as we can join our hands and fingers together in the same erect posture. Phil. Transf. No. 222.

PEARL *Colour*, in *Glass*. This beautiful colour is given to glass in the following manner: put tartar calcined to a whiteness into purified crystal, while in fusion, at several times, in small quantities, mixing it well every time, till the glass is become of the desired colour; and when it is, work it as quick as can be, for it is a colour that is quickly gone. See GLASS.

PEARL *Shell* or *Gaper*. See MYA.

PEARL, *Pin*, or *Web*, in *Medicine*, an unnatural speck, or thick film over the eye. See PANNUS.

Perambulator

PERAMBULATOR, in *Surveying*, an inftrument for the meafuring of diftances; called alfo *pedometer*, *way-wifer*, and *furveying-wheel*.

Its advantages are its handinefs and expedition: its contrivance is fuch, that it may be fitted to the wheel of a coach; in which ftate it performs its office, and meafures the road without any trouble at all.

There is fome difference in its make; that now moft ufual, and moft convenient, is as follows.

PERAMBULATOR, or *Way-wifer*, *conftruction of the*. The perambulator (reprefented *Plate* VI. *Surveying*, *fig.* 9.) confifts of a wheel two feet feven inches and a half in diameter; confequently half a pole, or eight feet and three inches in circumference. On one end of the axis is a nut, three quarters of an inch in diameter, divided into eight teeth, which, upon moving the wheel round, fall into the eight teeth of another nut *c*, fixed on one end of an iron rod Q, and thus turn the rod once round, in the time the wheel makes one revolution. This rod lying along a groove, in the fide of a carriage of the inftrument, has at its other end a fquare hole, into which fits the end *b* of the little cylinder P. This cylinder is difpofed under the dial-plate of a movement, at the end of the carriage B, in fuch manner as to be moveable about its axis. Its end *a* is cut into a perpetual fcrew; which falling into the thirty-two teeth of a wheel perpendicular to it, upon driving the inftrument forward, that wheel makes a revolution, each fixteen poles. On the axis of this wheel is a pinion with fix teeth, which, falling into the teeth of another wheel of fixty teeth, carries it round every hundred and fixtieth pole, or half a mile.

This laft wheel then carrying a hand or index round with it, over the divifions of the dial-plate, whofe outer limb is divided into one hundred and fixty parts, correfponding to the one hundred and fixty poles, points out the number of poles paffed over. Again, on the axis of this laft wheel is a pinion containing twenty teeth, which, falling into the teeth of a third wheel, that has forty teeth, drives it once round in three hundred and twenty poles, or a mile. On the axis of this wheel is a pinion of twelve teeth, which, falling into the teeth of a fourth wheel, that has feventy-two teeth, drives it once round in twelve miles.

This fourth wheel carrying another index over the inner limb of the dial-plate, divided into twelve, for miles, and each mile fubdivided into halves, quarters, and furlongs, ferves to regifter the revolutions of the other hand, and to keep account of the half-miles and miles paffed over, as far as twelve miles.

PERAMBULATOR, or *Way-wifer*, *ufe of the*. The application of this inftrument is obvious from its conftruction. Its proper office is in the furveying of roads, and large diftances, where a great deal of expedition, and not much accuracy, is required. It is evident, that driving it along, and obferving the hands, has the fame effect as dragging the chain, and taking account of the chains and links. See CHAIN.

Long diftances, fays major Rennell, may be accurately meafured by a perambulator; and he fays, that during the Bengal furvey, he meafured a meridian line of three degrees with this inftrument; and found it to agree minutely with the obfervations of latitude. An allowance, however, was made for the irregularities of the ground, whenever they occurred.

Petrol

PETROL, or PETROLEUM, in *Chemistry*, a fluid substance, resembling in a high degree the essential oils from vegetables. It is of a brownish-yellow colour, of a peculiar odour. Its specific gravity varies from .73 to .878. When exposed to a gentle heat for distillation, the fluid which comes over has less colour, is much thinner, and has more smell. In this state it is called naphtha. It burns with a white flame, and is employed in the vicinity of the Caspian sea for lamps. The earths in these parts are sometimes so saturated with it as to be rendered inflammable.

When it is exposed to the air, even that obtained by distillation, it becomes thick and highly coloured, and puts on the form of bitumen. This no doubt is occasioned by the gradual diminution of its hydrogen, by the oxygen of the atmosphere.

It is soluble in alcohol and ether, and combines with the fixed and volatile oils. It is hence used to dissolve resinous bodies and bitumen, and might, in many cases, answer the purposes of oil of turpentine.

It is found in different states. According as it has had access to the air, it will thicken and become of a darker colour. See NAPHTHA and BITUMEN.

The more fluid petrolea, says Dr. Lewis, have been distinguished by the name of *naphtha;* and the thicker by those of *pissasphalthum* and *pissel**eum*.

These, according to all appearance, must be the work of subterraneous fires, which raise or sublime the more subtile parts of certain bituminous matters that lie in their way.

These parts, being condensed into a liquor by the cold of the vaults of rocks, are there collected, and ooze thence through clefts and apertures, with which the disposition of the ground furnishes them.

Petrol, then, is a liquid bitumen, only differing by its liquidity from other bitumens, as asphaltum, jet, amber, and the like substances.

The naphtha, which is either a liquid, or at least a very soft bitumen, is nearly allied to petrol.

Hitherto there has been little petrol found, except in hot countries. Olearius says, he saw above thirty springs of it near Scamachia, in Persia. (See PERSIA.) There are also petrols in the southern provinces of France; but the best are those in the duchy of Modena, first discovered by Ariosto, a physician, in 1640, in a very barren valley, twelve leagues from the city of Modena.

Three canals are there dug with great expence in the rock; by which three different kinds of petrol are discharged into little basons or reservoirs: the first, as white, clear, and fluid as water, of a brisk penetrating smell, and not disagreeable; the second of a bright yellow, less fluid, and of a less brisk smell than the white; the third of a blackish red, of thicker consistence, and a smell more approaching that of bitumen.

There are many varieties of these oils in regard to colour, fluidity, subtility, and the pungency of their smell, and taste; the most fluid are, in general, the most subtile and pungent. With us they are commonly sophisticated.

Mr. Boulduc made ſeveral experiments with the petroleum of Modena, an account of which he gave to the Paris Academy.

It eaſily took fire on being brought near a candle, and that without immediately touching the flame; and when heated in any veſſel, it will attract the flame of a candle, though placed at a great height above the veſſel, and the vapour it ſends up taking fire, the flame will be communicated to the veſſel of heated liquor, and the whole will be conſumed. It burns in the water, and when mixed with any liquor, ſwims on the ſurface of it, even of the higheſt rectified ſpirit of wine, which is one-ſeventh heavier than pure petroleum. It readily mixes with all the eſſential oils of vegetables, as oil of lavender, turpentine, and the reſt, and ſeems very much of their nature: nor is this very ſtrange, ſince the alliance between theſe bodies is probably nearer than is imagined, as the eſſential oils of vegetables may have been originally mineral ones, and drawn up out of the earth into the veſſels of the plant.

Petroleum, when ſhaken, yields a few bubbles; but they ſooner ſubſide than in almoſt any other liquor, and the liquor reſumes its clear ſtate again almoſt immediately. This ſeems owing to the air in this fluid being very equally diſtributed in all its parts, and the liquor being compoſed of particles very evenly and nicely arranged.

The extenſibility of this oil is alſo amazing. A drop of it will ſpread over ſeveral feet of water, and in this condition it gives a great variety of colours, that is, the ſeveral parts of which this thin film is compoſed, act as ſo many priſms.

The moſt ſevere froſt never congeals petroleum into ice, and paper wetted with it becomes tranſparent, as when wetted with oil; but it does not continue ſo, the paper becoming opaque again in a few minutes, as the oil dries away.

Spirit of wine, which is the great diſſolvent of ſulphur, has no effect upon petroleum, not even with ever ſo long a digeſtion. It will not take fire with the dephlegmated acid ſpirits, as oil of cloves and other of the vegetable eſſential oils do: and in diſtillation, either by balneum Mariæ, or in ſand, it will neither yield phlegm nor acid ſpirit; but the oil itſelf riſes in its own form, leaving in the retort only a little matter, thick as honey, and of a browniſh colour. Whoever, therefore, would uſe this oil in medicine, muſt take it as nature has prepared it, art having no power to make any alteration in it. Mem. Acad. Paris, 1715.

It is remarkable, that all the petroleum got from the lake of mount Ciaro in Italy is white, whereas that of Modena is yellow, and that of Parma brown. Theſe wells or holes continue to furniſh the oil in different quantities for a conſiderable time, and, when they will yield no more, they pierce the ſlates in ſome other place. Mem. Acad. Scienc. Par. 1736.

The petroleum wells of the Birman empire, ſituated about five miles E. of Yayuangheoum, or Petroleum creek, on the Irrawaddy, ſupply the whole empire, and many parts of India, with this uſeful product. The mouth of the creek, when captain Symes viſited it, was crowded with large boats, waiting to receive a lading of oil; and immenſe pyramids of earthen jars were raiſed within and round the village, diſpoſed in the ſame manner as ſhot and ſhells are piled in an arſenal. This place is inhabited only by potters, who carry on an extenſive manufactory: the ſmell of the oil is ſaid to have been extremely offenſive. (Symes's Embaſſy to Ava, vol. ii.) Of the wells in this diſtrict there are ſaid to be 520, which yield, annually, more than 400,000 hogſheads of petroleum.

Petroleum *Barbadenſe*, *Barbadoes tar*, a ſpecies of *bitumen*, for an account of which, ſee Bitumen. Petroleum is a ſtimulating antiſpaſmodic and ſudorific; and as ſuch it has been given in aſthma and coughs, unattended with inflammation, but it is chiefly uſed for external purpoſes, as a ſtimulant in diſeaſes of the hip-joint, rheumatic, and other chronic pains, chilblains, and to paralytic limbs, applied by friction. It is, however, ſcarcely ever employed in either way, and on this account is not often to be procured in the ſhops. The doſe of petroleum may be from ♏x to f℥ſs, in any convenient vehicle. In the Weſt Indies the Barbadoes tar is uſed both as an internal remedy and an external application, in the ſame caſes.

Phosgene gas

PHOSGENE GAS, in *Chemiſtry*, a ſpecies of gas lately diſcovered by Mr. John Davy, in his efforts to unite together the carbonic oxyd and the oxymuriatic gaſes. Some unſucceſsful attempts had been made for this purpoſe by Meſſrs. Gay-Luſſac and Thénard, and afterwards by Mr. Murray of Edinburgh. Mr. Davy accompliſhed this object apparently without any difficulty. The gaſes were put in contact and expoſed to a bright light for a quarter of an hour; when the mixture was diminiſhed to half its original bulk, and a gas was left, which poſſeſſed ſeveral remarkable properties. It is compoſed of equal volumes of chlorine and carbonic oxyd gaſes, condenſed into half their bulk. It is colourleſs; and has a ſtrong diſagreeable ſmell. Its ſpecific gravity is 3.669; and 100 cubic inches, under a mean temperature and preſſure, weigh 111.91 grains; hence it is by far the heavieſt gas at preſent known. It reddens vegetable blues. It combines with ammonia, condenſing four times its bulk of that gas, and forming a peculiar neutral ſalt. Phoſgene gas is decompoſed by water, and by moſt metallic bodies. It is an acid of a very peculiar nature, and deſerves a much more complete examination. As this gas has been hitherto produced only by the action of light, Mr. Davy propoſed to name it "phoſgene." Phil. Tranſ. for 1812, part i.

Phosphorus

PHOSPHORUS, Φωσφορος, formed from φως, *light*, and φερω, *I bear*, a matter, which ſhines, or even burns, ſpontaneouſly, and without the application of any ſenſible fire.

Phoſphori are either *natural*, or *artificial*.

PHOSPHORI, *Natural*, are matters which become luminous at certain times, without the aſſiſtance of any art or preparation.

Such are the glow-worms, frequent in our colder countries; lantern-flies, and other ſhining inſects, in hot countries; rotten wood; the eyes, blood, ſcales, fleſh, ſweat, feathers, &c. of ſeveral animals; diamonds, when rubbed after a certain manner, or after having been expoſed to the ſun or light; ſugar and ſulphur, when pounded in a dark place; ſea-water, and ſome mineral waters, when briſkly agitated; a cat's or horſe's back, duly rubbed with the hand, &c. in the dark; nay, Dr. Croon tells us, that upon rubbing his own body briſkly with a well-warmed ſhirt, he has frequently made both to ſhine; and Dr. Sloane adds, that he knew a gentleman of Briſtol, and his ſon, both whoſe ſtockings ſhone much after walking.

All natural phoſphori have this in common, that they do not ſhine always; and that they never give any heat.

The natural phoſphori are either foſſile, vegetable, or animal.

The foffile are, though very different in degree, fome forts of earths, white fand, limeftones, ftalactites, and feveral other figured ftones, ifland cryftals, flints, fome fpecies of agates, white arfenic; but no fort of metals, metallic or fulphureous bodies, as jet, amber, except the before-mentioned arfenic.

On the other hand, falts imbibe light, provided they are divefted of every metallic principle; otherwife not, though as pellucid as poffible. For this reafon none of the vitriols will imbibe light; but other falts will though with a confiderable difference as to quantity; for fal gem and rock falt imbibe very little; fea falt, if dry, and in cryftals, much more; and, in like manner, fal ammoniac, fal catharticum, and nitre yet more. This power is weak in the natron of the ancients, and alum; but brighteft of all in borax.

In the vegetable kingdom we find very few phofphori; that of dry rotten wood is weak and not lafting; it appears chiefly upon the edges and inequalities of the furface. But this is moft remarkable in the rotten wood of the firtree, and fome others, where, in the dark, you fee fhining fpots as big as tares; whereas in full light the whole furface appears alike. Some few bars are luminous, but not confiderably fo; but no fruits, feeds, or their meals. Cotton, and the cryftals of tartar, appear very bright, but fine loaf-fugar appears the moft luminous of all both without and within; gums and refins retain no light.

There is a vaft variety of phofphori in the animal kingdom, fuch as the bones and teeth; to thefe may be added the fhells of fifh, egg-fhells, the human calculus, bezoar, and thofe parts of animals in which the terreftrial principle is very predominant. But where there is a confiderable quantity of oily matter, as in the hoofs, horns, and feathers, no light is manifeft, or at leaft in a fmall degree. Light is vifibly retained by the fkins of feveral living animals. Water cannot be made to imbibe light, though ice does exceedingly well, and efpecially fnow.

Beccarius propofes fome queries concerning the natural phofphori, of which the firft is, in what and how great a light the object ought to be placed? He tried different phofphori, in different degrees of light, and found them imbibe moft light from the fun itfelf; next in quantity when the fky was clear; and the leaft in foggy weather. Thefe experiments fhould be made in the open air, and not in a houfe with the glafs-windows fhut; becaufe many bodies appear luminous when the light has come directly to them, which will not have that appearance when the light has paffed through the glafs. He laftly tried what light they would imbibe from very bright flame, and found that alabafter itfelf, which is faturated more than any fubftance by the fun's rays, imbibed exceedingly little. The next query is, how long thefe bodies fhould remain in the light to be fufficiently faturated? Four or five feconds were found the utmoft length of time required for that purpofe. The other query is, how long the received light will continue in thefe phofphori? It does not laft the fame time in all; but continues more or lefs, from two feconds to eight, in proportion to the ftrength of the phofphorus, and the quantity of light received.

But that which, of all natural phofphori, has occafioned the greateft fpeculation, is the

Phosphorus, *Barometrical*, or *Mercurial.* M. Picard firft obferved, that the mercury of his barometer, when fhaken in a dark place, emitted light; with this circumftance, that in fhaking the mercury with rapidity, fometimes above, and fometimes below its equilibrium with the air, the light was only feen when below it, where it appeared as if adhering to the upper furface.

But this light is not found in the mercury of all barometers; which occafions a great difficulty.

M. Bernouilli, upon examining the circumftances of this phenomenon, invented a folution of the fame; he imagines, that upon the mercury's defcending, the vacuum in the tube increafing, there iffues out of the mercury to fill up this excefs of vacuity, a very fine fubtile matter, before difperfed throughout the pores of this mineral; and that, at the fame time, there enters through the pores of the tube another fine matter: thus, the firft matter emitted from the mercury, and collected over its furface, ftriking impetuoufly againft that received from without, has the fame effect with Defcartes' firft element againft the fecond; that is, it produces the motion of light.

But why, then, is not the phenomenon common to all barometers? To this he anfwers, that the motion of the fubtile matter out of the mercury may be weakened, and prevented, by any heterogeneous matter collected on its upper furface, into a kind of pellicle, fo that the light fhould never appear, but when the mercury is perfectly pure. This reafoning feemed confirmed from the experiments of feveral barometers, which he made according to this plan; but the Royal Academy of Sciences, repeating experiments with barometers made after the fame manner, did not meet with the fame fuccefs; the light being found in fome, but not in others.

M. Homberg, therefore, conjectured, that the difference confifted in the different qualities of the quickfilver: in fome, he obferved, they ufed quick-lime to purify it; in others, fteel-filings. The mercury, then, rifing in the diftillation, and paffing through the lime, might take away fome parts thereof, capable, by their extreme fmallnefs, of lodging in its interftices.

Hence, as quick-lime always retains fome fiery particles, it is poffible, in a place void of air, where they fwim at liberty they may produce this luftre.

Mr. Hauksbee has feveral experiments on the mercurial phofphorus. Paffing air forcibly through the body of quickfilver, placed in an exhaufted receiver, the parts were violently driven againft the fide of the receiver, and gave all round the appearance of fire; continuing thus till the receiver was half-full again of air.

From other experiments he found, that though the appearance of light was not producible by agitating the mercury in the fame manner in the common air, yet that a very fine medium, nearly approaching to a vacuum, was not at all neceffary.

And, laftly, from other experiments he found, that mercury inclofed in water, which communicated with the open air, by a violent fhaking of the veffel wherein it was inclofed, emitted particles of light in great plenty, like little ftars.

By including the veffel of mercury, &c. in a receiver, and exhaufting the air, the phenomenon was changed; and, upon fhaking the veffel, inftead of fparks of light, the whole mafs appeared one continued circle of light. Farther, if mercury be inclofed in a glafs tube, clofe ftopped, that tube is found, on being rubbed, to give much more light, than when it had no mercury in it. When this tube has been rubbed, after raifing fucceffively its extremities, that the mercury might flow from one end to the other, one fees a light creeping in a ferpentine manner all along the tube; that is to fay, the mercury is all luminous. The mercury, being made to run along the tube

afterwards without rubbing it, was found to emit some light, though much less than before: this proves that the friction of the mercury against the glass, in running along, does in some measure electrify the glass, as the rubbing it with the hand does, only in a much less degree. This is more plainly proved by laying some very light down near the tube, for this will be attracted by the electricity raised by the running of the mercury, and will rise to that part of the glass along which the mercury runs; and it is very plain from this, that what has been long known in the world under the name of the phosphorus of the barometer is not a phosphorus, but merely a light raised by electricity, the mercury electrifying the tube. Phil. Transf. N° 484. See ELECTRICITY and MERCURY.

PHOSPHORI, *Artificial*, are such as owe their luminous quality to some art or preparation.

Phosphori are, it is well known, often produced by art; some are made by the maceration of plants alone, and without any fire; such as thread, linen cloth, but above all paper. The luminous appearance of this last, which is now known to be an electrical phenomenon, is greatly increased by heat. This is confirmed by two experiments; the first is, by exposing the paper, spread upon an iron grate, to the naked fire, yet not near enough to rescorch it, and then laying a warm brick thereon to retain the heat; by which means it was observed, that where the paper was not screened by the iron grate, it was most luminous; so that by the lights and shades you might distinguish in the dark the image of the iron grate a considerable time. The other experiment is, the application of the paper to a plate of warm brass; from which, when in the dark, you might very easily, by its being less luminous, distinguish the margin of the paper that had not been warmed by the brass.

However Beccarius, though he acknowledges that paper, after having been made red-hot and cooled again, is an excellent phosphorus, found, that it was much injured by being exposed to the light of the sun. He made experiments to the same purpose with a great variety of substances, mineral, vegetable, and animal; and observed, that the effects were the same, and that the stronger the light was, and the longer they were exposed to it, the more injury they received: and he found also, that the injury they received was lasting.

The same author takes notice also of those phosphori which become so by the assistance of fire; but the fire here spoken of is not great enough to dissolve their constituent parts, but only such as may affect the external parts of their texture, and that but gently; so that the process here mentioned is only drying or roasting. For it is not the watery or the saline parts in bodies which are torrified, but the oleaginous, with which many vegetables, and most animals abound. The white flesh of animals, such as that of chickens, become a phosphorus by roasting, as well as the tendons; and whatever parts of animals become glutinous by boiling, such as carpenters' glue, isinglass, &c. to these may be added cheese. Bones, though they imbibe light without any preparation, have that property in a much greater degree when burnt, and their luminous appearance is much more lively. But roasting has not this effect upon feathers, hoofs, horns, and only in a small degree on whites of eggs, though the yolk when dry easily became a phosphorus.

The same operation which produces several phosphori from the animal kingdom, gives also several from the vegetable. Thus, by gently roasting gums, as myrrh, gum tragacanth, and others, they appear luminous, though different in degrees; and this light is clear in proportion to the gentle evaporation of the aqueous parts. By this treatment nuts of every kind, pulse, corn, coffee-berries, meal, bread, and wafers, also become phosphori. Turpentine, amber, and some resins, require more fire before they imbibe light; so that you must divest them of their acid, and their light etherial oil, to make them appear luminous. But here great care must be taken that they boil no longer than from being white they turn yellow; for, if you proceed longer, your labour is lost. Those phosphori produced by torrefaction soon lose their power, which, perhaps, neither time, nor a thorough dissolution of their parts, can deprive the natural ones of. In general, as long as the phosphori gained by torrefaction preserve their power, their light is more sharp and striking, but the natural more weak. Those that are gained by calcination, and Baldwin's phosphorus, seem to possess both the striking light of those gained by torrefaction, and the weaker light of the natural phosphori: the last they preserve a long time, but the former is lost, by degrees, much sooner. The well calcined ashes of plants, or rather their terrestrial parts, remaining after the solution of their fixed salts by washing, and neutral salts, continue phosphori after many years: so that, as far as we can judge, the luminary power which is gained by calcination, though not so intense, continues perpetual; whereas, that gained by torrefaction always decreases, and, in a very little while, is no longer visible. Some, even by this method, continue to imbibe light much longer than others. Gum arabic, which continues longest, lasts six days; bread not one, and coffee only a few minutes. However, at any time, by a fresh torrefaction, you may recover these languid phosphori; in which property they have great likeness to the Bolognian stone, and other phosphori prepared by art.

Almost all bodies, by a proper treatment, have that power of shining in the dark, which, at first, was supposed to be the property of one, and afterward only of a few. How this is brought about is not easy to solve. If we suppose, with some, that the light from a luminous body enters and abides in the phosphori; we shall find somewhat new to admire in light itself. It is no new opinion, that this fluid consists of very fine particles, which are continually darted forth from a luminous body in all directions, with a very great velocity: but it has by nobody been laid down hitherto, that these particles are not dissolved by the violence of their agitation, nor dispersed, nor immediately cease to exist; but subsist still, and adhere to what bodies come in their way, as heat does. If, therefore, the particles of light are not dissolved as soon as they are emitted from a radiant body, but continue some time, what else is required but that we allow its atmosphere to every lucid appearance? If the phosphori shine with a borrowed light, but not with their own, and that only when put in motion, and fired by the rays of a shining body, which some experiments seem to confirm, then other new doctrines will arise. There must be then a hidden, a secret principle in bodies, to be lighted up by this most subtle fire. There will be in the universe a certain perpetual fire from these phosphori; the matter of which, though constantly dissipated by burning, does not waste enough to be obvious to our senses. See Phil. Transf. N° 478. in vol. xliv. art. 17. p. 83. and Beccarii Com. p. 52. 91, &c. See LIGHT, LIGHT *from Diamonds*, and *Bolognian* PHOSPHORUS, *infra*.

Of artificial phosphori there are three principal kinds: the first *burning*, which consumes every combustible it touches; the other two have no sensible heat; and are

called the *Bononian* and *Hermetic* phosphorus, to which class others of a similar kind may be reduced.

PHOSPHORUS, *Burning*, in *Chemistry*, is a simple inflammable substance.

The discovery of this phosphorus was first made in 1677, by one Brandt, a citizen of Hamburgh, in his researches for the philosopher's stone. Brandt communicated the secret to one Kraaft, of Dresden, but withheld it from Kunckel; upon which this chemist, knowing that urine was the substance employed, succeeded in his attempts of making phosphorus; accordingly, this phosphorus is commonly called *Kunckel's* phosphorus, after his name. A similar phosphorus was also made by Mr. Boyle, after having seen a piece of it in the hands of Kraaft, who brought it to London in 1679, in order to shew it to the king and queen of England; having been only informed that this phosphorus was produced from some matter belonging to the human body. Kraaft, indeed, told Stahl, that he had communicated the process for making it to Mr. Boyle; but this is such an imputation on the integrity and honour of our English philosopher, as can by no means be admitted on the testimony of a man, who had been treacherous to Kunckel, who traded in the secret of making phosphorus, and after selling it to many persons, published the process for making it in the Mercure Galont, for June 1683. Kunckel, and a German chemist called Godfreid Hantkwitz, to whom Boyle communicated the method of preparing it, were the only persons who made it in any considerable quantities.

M. Hellot, in his Memoir upon this subject, Ac. Paris, 1737, enumerates all the processes for making it, that were in use soon after the discovery of it; *viz.* that published by Mr. Boyle in 1680, in the Phil. Transf. N° 196. (see Phil. Transf. Abridg. vol. iii. p. 346.); that of Kraaft; that of Brandt, in a collection of experiments and observations of Dr. Hooke, published by Dr. Derham in 1726; that of M. Homberg, in the Ancient Memoirs of the Academy, in 1692; and those found in the works of several chemists, particularly of Theickmeyer, Hoffmann, and Niewentyt. However, the operation continued in a great degree a secret till the year 1737, when a stranger came into France, and obtained a reward f. n the ministry for communicating his process, which was executed by Messrs. Hellot, Du Fay, Geoffroy, and Duhamel. Since the publication of M. Hellot's Memoir, the operation has been no longer a secret; though seldom executed, because it was rather curious than useful, and both troublesome and expensive.

The solid phosphorus was formerly prepared from urine in the following manner. Evaporate a good quantity of urine of beer-drinkers to the consistence of honey; cover it up in an earthen vessel, and set it three or four months in a cellar to ferment and putrefy. Mix two parts of sand, or powder of pot-sherds, with one part of this urine, and put it into a retort, fitted to a long-necked receiver, with two or three quarts of water in it. Distil it in a naked fire, in a reverberatory furnace; at first gently; after two hours, augment the fire gradually, till all the black fetid oil be drawn off. Raise the fire to the highest degree; upon which white clouds will come into the receiver, and fix, by little and little, on one side, in form of a yellowish skin; and another part will precipitate to the bottom in powder. Keep the fire thus violent for three hours, till no more fumes arise. Let all cool, and unloose the vessels; and, throwing more water into the receiver, shake all well about, to loosen what sticks to the sides. Pour the whole into a glass vessel, to settle.

The volatile salt will now dissolve in the water, and the phosphorus and oil will sink to the bottom; then pour off the water, and gathering the remaining part together, put it into a glass vessel, with a little fresh water, and digest it in a sand-heat, stirring it from time to time with a wooden spatula.

By this means, the phosphorus will separate from the oil, and sink to the bottom: pour off the oil, and make up the phosphorus, while hot, into sticks for use.

Boerhaave gives us other ways of preparing phosphorus. Recent urine, he observes, digested three or four days in a tall glass, with a heat no greater than that of a healthy man, grows ruddy, fetid, and cadaverous; this digested urine, being put to distil in a retort, yields a clear, fetid liquor, then a yellow volatile salt, which evaporated to the consistence of a sapo, and mixed with four times its weight of dry sand, and the distillation continued in a covered retort, there successively comes over, by greater and greater degrees of fire, a fetid brown oil, blueish fumes, and, finally, a gross shining matter, which sinks in water, and is the solid phosphorus.

To make it more easily, and to the best advantage, it may be proper to take a sufficient quantity of human urine, afforded by a person not much given to drink wine, and exhale it away in an open vessel to a rob, or the consistence of honey; then set it to putrefy for half a year, and, upon distillation, it will afford a large proportion of salt, after which, if six times its own quantity of sand, or brick dust, be added to the remainder, and the distillation be continued, as in the case last mentioned, the phosphorus will fall into the water. Or it may commodiously be prepared, by suffering the rob of urine to digest for two years in an open vessel in the open air; during which time, a slimy, feculent, unctuous, earthy matter, will fall to the bottom; which, being frequently washed with pure water, wherein it will not dissolve, will leave a white matter behind it, neither of an alkaline, acid, saline, or terrestrial, nor scarcely of an unctuous nature: and this is of itself a proper matter for the making of phosphorus by distillation with sand.

In order to preparing the phosphorus, and indeed most of the other preparations of urine, the first step is to reduce that liquor to the consistence of a rob or thick extract; those who have worked on this subject sufficiently know how abominably nauseous and disagreeable a task this is. The operator alone is not the person who is almost poisoned by it, but the whole neighbourhood is affected; and it is well known, that our Godfrey, who used to prepare large quantities of this substance, was always obliged to keep a house in the fields to perform this part of the process in.

There is an easy and excellent method proposed by Stahl for the performing of this troublesome business, by means of condensation by cold or freezing. There needs no more than to expose the proper quantity of urine to some frosty nights in winter; or at any time of the year to our ice-houses, or other places where ice is preserved all the year round. The frost will, in this case, affect a large part of the urine, but not the whole; and the liquid part being separated from the solid ice, it will be found that the watery parts alone have suffered the freezing, and that all the unctuous and saline ones are left behind in the unfrozen part, which is, by repeated freezings of its yet remaining aqueous parts, at length reduced to that sort of rob which is required for all the purposes of distillation, and that without any trouble or offensiveness, either to the operator or any body else. The power of condensation by freezing in this manner, extends to wine, vinegar, and all fermented

liquors; but it operates differently on the several different ones, and is to be regulated according to their natures. The natural cold of our climate is seldom too great for any of the liquors we desire to condense; that is, it is never so great as to condense the whole into ice. It often is not sufficiently great to condense the aqueous part, even after ever so many repetitions. In this case, it may be proper to bring in the use of the common freezing mixtures, made with ice, or snow and salt. To suit the artificial degree of cold, in these cases, requires care and experience, and is almost as nice a point as the suiting of the degrees of heat in the operations of chemistry.

In 1743, Mr. Margraaf published, in the Memoirs of the Academy at Berlin, a new and excellent process for obtaining more easily and expeditiously, and at less expence than had hitherto been done, a considerable quantity of phosphorus. In his process, a kind of plumbum corneum is previously prepared, by distilling a mixture of four pounds of minium with two pounds of powdered sal ammoniac; the residuum after the distillation, or the plumbum corneum, is to be mixed with nine or ten pounds of extract of putrefied urine, boiled to the consistence of honey. This mixture is to be made slowly in an iron cauldron set upon the fire, and by frequently stirring the contents. Half a pound of powdered charcoal is then to be added, and evaporation is to be continued till the whole is reduced into a black powder, which is to be put into a retort, in order to extract from it, by a moderate and gradual heat, all the volatile products of urine, that is, volatile alkali, fetid oil, and an ammoniacal matter which adheres to the neck of the retort. In this distillation the heat is only to be raised so as to make the matter red-hot. After the distillation a black and friable residuum is left, from which the phosphorus is to be extracted by a second distillation, and a stronger heat. Before it is exposed to another distillation it may be tried by throwing some of it upon hot coals. If the matter has been well prepared, a smell of garlic exhales from it, and a blue phosphorical flame is seen undulating along the surface of the hot coals. This matter is to be put into a good earthen retort, capable of sustaining a violent fire, and which may be secured with a covering of clay and hair. Three quarters of the retort are to be filled with the matter which is to yield the phosphorus. It is to be placed in the common furnace for distillation with a retort; excepting that instead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to six inches, according to the size of the furnace, and the height from eight to nine feet. This apparatus, which Mr. Beaumé uses, is necessary for raising a sufficient heat, and for the convenience of throwing in a sufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate size, pierced with a small hole, and half full of water. For this purpose ordinary fat lute may be bound on with strips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort passes ought to be well stopped with furnace-earth. Lastly, a small wall of bricks is raised betwixt the furnace and the receiver, to guard this vessel against heat as much as is possible.

All these preparations being made the evening before the distillation is to be performed, we are then capable of proceeding to this operation, which is very easy. The retort is to be heated by slow degrees during an hour and a half; and then the heat is to be increased till the retort be red-hot, and the phosphorus begin to pass in luminous vapours: when the retort is almost of a white-red heat, the phosphorus passes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more passes into the receiver. When a retort contains eight pints or more, this operation continues about five hours.

Mr. Margraaf's apparatus is somewhat different from that above described. He divides the whole quantity of matter from which the phosphorus is to be obtained into six small retorts, which he places in a furnace that he describes. The advantage of this division is, that if any accident happens to one retort, the whole matter is not lost; and as the retorts are smaller, a less heat is required. If, indeed, much phosphorus was to be made, this practice would be safe and excellent; but Macquer affirms, that the method above described of Mr. Beaumé is very convenient when a large quantity of phosphorus is not wanted, and that he has never seen it fail.

Phosphorus does not pass pure in this distillation, but is blackened by soot or coal, which it carries along with it: it may be easily purified, and rendered white and fine by a second distillation or rectification. This rectification is made in a small glass retort, to which is adjusted a small receiver half full of water. A very gentle heat is sufficient, because phosphorus once formed is very volatile: and as the fuliginous matters with which it is soiled were raised merely by the violence of the heat, they remain at the bottom of the retort in this distillation, and the phosphorus passes very pure.

The phosphorus is then usually divided into small cylindrical rolls, for the conveniency of using it. This is done by putting it in glass tubes immersed in warm water. This very gentle heat is sufficient to liquefy the phosphorus, which is almost as fusible as suet. It takes the form of the glass tubes, from which it may be taken out when it is cold and hardened. That it may be more easily taken out of the tubes, these must be somewhat of the form of frustums of cones. All these operations ought to be made under water, to prevent the inflammation of the phosphorus.

Phosphorus is now usually procured by the following process. Calcine a quantity of bones till the whole of their inflammable matter is consumed, which will be indicated by their whiteness. After they are reduced to a fine powder, let 100 parts, by weight, be mixed with 500 parts of water, in a vessel of stone ware, or any other which sulphuric acid will not act upon. To the above mixture add, by degrees, 40 parts of sulphuric acid, constantly stirring the mixture with a stick or a glass rod. After the effervescence has subsided, let the mixture stand for a day or two, then decant off the clear liquor, which is to be preserved. Let the residuum be agitated with a quantity of fresh water, and thrown upon a filtre, adding the clear liquor which runs through to that decanted in the first instance. Let more water be poured upon the filtre till it comes through tasteless. This being added to the last, the whole will contain a super-phosphat of lime, with great excess of acid. In order to separate the phosphoric acid from the lime, the nitrat of lead is to be added. Phosphat of lead precipitates in the state of white powder, while the lime is dissolved in the nitric acid. The phosphat of lead being very ponderous, may be separated by decantation and repeated washing. When the powder is dried, mix it with one-eighth its weight of charcoal powder, and put it into an earthen retort. The common earthen retorts are seldom fitted for this process, being very liable to crack. The clay of which they are formed should be mixed with coarsely powdered cru-

cibles, to render the texture of the ſubſtance when baked more open. The outſide muſt be coated with white lead and flint, to form a glazing during the diſtillation of the phoſphorus. Without this precaution the vapour of the phoſphorus would eſcape through the pores of the veſſel. The retort, with its contents, muſt be placed in an air-furnace, with a ſlit in the ſide to admit the neck of the retort. The fuel ſhould be well burnt coaks, and the fire raiſed very gradually. The neck of the retort ſhould be luted to an adopter, which is fitted to a glaſs receiver, previouſly filled with azotic gas. A ſmall tube ſhould proceed from another opening in the receiver, terminating in a pneumatic trough. This ſerves to carry off the elaſtic fluids which are diſengaged in the proceſs. During the firſt ſtage of the proceſs carbonic acid is diſengaged, which is afforded by the carbon combining with the oxygen of the phoſphoric acid and the oxyd of lead. The charcoal always contains a portion of moiſture, which is decompoſed by the carbon. In the laſt ſtage of the proceſs, when the phoſphorus riſes in the elaſtic form, a portion of it combines with the hydrogen of the water, forming phoſphoretted hydrogen gas, which takes fire when it comes in contact with oxygen of the atmoſphere. This ſpontaneous inflammation of the eſcaping bubbles, is a certain ſign that the phoſphorus is coming over. It is ſeen running down the adopter into the receiver, which contains a ſmall portion of water for it to drop into. The maſs which drops into the water is generally of a browniſh, and ſometimes a darker colour, and conſiſts of phoſphorus, containing ſome carbon, and is otherwiſe impure. When the apparatus is quite cold, it may be taken out, and placed in a glaſs funnel provided with a long cylindrical neck, about one-fourth of an inch in diameter, cloſed at one end with a cork. It is firſt filled with cold water, ſo as to cover the phoſphorus. The whole is now immerſed into hot water, which melts the phoſphorus which is cauſed to occupy the interior of the tube, aſſuming a pale yellow colour, while that in the top part of the tube is of a darker colour, and contains the impurities. The pure part is broken into pieces, in which ſtate it is ſold. If the phoſphorus after diſtillation be very impure, it ſhould be diſtilled a ſecond time from a glaſs retort, obſerving the ſame precautions in the receiver as in the firſt proceſs. After this it may be ſtrained through chamois leather under hot water.

The phoſphat of lead may alſo be procured by adding nitrat of lead to urine. The latter ſubſtance contains a quantity of the phoſphats of ſoda and ammonia, each of which give up their acid to the lead, forming phoſphat of lead, which falls to the bottom of the veſſel in the ſtate of an inſoluble white powder. This is doubtleſs the cheapeſt way of getting phoſphorus.

Stahl ſuppoſed phoſphorus to be a compound of muriatic acid with phlogiſton; but it was afterwards proved by the reſearches of Margraaf, that muriatic acid could not be produced by burning phoſphorus, nor could he ſucceed in forming phoſphorus by treating muriatic acid with inflammable bodies. He found in the courſe of his experiments, what has ſince led to the overthrow of the phlogiſtic doctrine. The phoſphorus gained weight by burning, and he called the ſubſtance reſulting from the combuſtion phoſphoric acid. Lavoiſier, in a ſatisfactory manner, confirmed the facts of the above chemiſt, by burning phoſphorus in oxygen gas. The diminution of the oxygen he found juſt equal to the increaſe of weight in the phoſphorus after burning. Hence it was eſtabliſhed, that phoſphoric acid was a compound of phoſphorus and oxygen.

Phoſphorus, when perfectly pure, is of a pale yellow colour, having ſome reſemblance to white wax. Like the latter ſubſtance it ſoftens by heat, and is ſo ductile as to be cut with a knife.

It is called "phoſphorus fulgurans" from its corruſcations; and "phoſphorus ſmaragdinus," becauſe its light is frequently green or blue, eſpecially in places that are not very dark.

It is alſo called "ſolid phoſphorus," from its conſiſtence.

It diſſolves in all kinds of diſtilled oils; and, in that ſtate, is called the "liquid phoſphorus."

It may be ground in all kinds of fat pomatums; in which caſe it makes a luminous unguent.

So that the phoſphorus fulgurans, ſmaragdinus, ſolid and liquid phoſphorus, and luminous unguent, are all the ſame preparation, under different circumſtances. See FULGURATING *Phoſphorus*.

The ſpecific gravity of phoſphorus is about 1.77; the fuſing point is 90° Fahr.; and it aſſumes the form of vapour at a little ſhort of 600°.

When phoſphorus is heated to 148 in the open air, it takes fire and burns with great brilliancy, owing to the rapidity with which it combines with oxygen. Very denſe white fumes are produced, ſo as ultimately to nearly obſcure the flame. If the combuſtion be made in a veſſel, the fumes adhere to its ſides, and become liquid, by attracting moiſture from the atmoſphere. A portion of red matter is left after the burning has ceaſed, which is probably a compound of phoſphorus and carbon. The liquid which is formed upon the ſides of the veſſel has an acid taſte, and conſiſts of phoſphoric acid, water, and probably a ſmall quantity of phoſphorus which has eſcaped combuſtion. When phoſphorus is burnt in pure oxygen, the light produced is of ſuch dazzling ſplendour as to give pain to the eyes. The combuſtion is by this means complete, and if the oxygen is in ſufficient quantity, the whole is converted into phoſphoric acid.

Lavoiſier found that 100 grains of phoſphorus took up 154 grains of oxygen, ſuppoſing the atom of oxygen to be 7, hydrogen being 1, agreeably to the numbers of Dalton. And conſidering the phoſphoric acid as an atom of phoſphorus with two atoms of oxygen, we have $\frac{154}{100} = \frac{14}{9.1}$. Dalton has fixed the atom of phoſphorus at 9. From theſe data the atom of phoſphoric acid will be $9 + 2 \times 7 = 23$.

When phoſphorus is expoſed to the air in ſmall bits, it gives out a white ſmoke for ſome time, and is ultimately changed into a clear vivid oily liquid, which has an acid taſte. In this proceſs it combines ſlowly with oxygen, and conſiſts of one atom of phoſphorus with one of oxygen, or $9 + 7 = 16$. When phoſphorus is made to undergo ſlight combuſtion, by melting it over the interior of a phial, with the preſence of ſmall quantities of air, the phoſphorus aſſumes a reddiſh colour. By this change it is found to take fire with much greater facility, ſo much ſo that this proceſs is reſorted to in the conſtruction of the common fire bottles.

From this and other facts it is probable that an oxyd of phoſphorus exiſts with leſs oxygen than is contained in phoſphorous acid. It doubtleſs is conſtituted by 2 atoms of phoſphorus to 1 of oxygen, or $2 \times 9 + 7 = 25$. See PHOSPHOROUS and PHOSPHORIC *Acids*.

The action of the acids upon phoſphorus is treated under the reſpective acids, but what has been omitted under OXYMURIATIC *Acid*, we ſhall introduce here.

The muriatic acid does not act upon phoſphorus when the acid is in the gaſeous form, but when preſented in combination with ſome other bodies, it forms very curious combinations, which have been little noticed. We are

indebted to sir Humphry Davy for our knowledge of these facts.

When phosphorus is immersed in oxymuriatic acid gas, it burns with a pale flame, producing a white substance, which adheres to the sides of the vessel. The above chemist found that one grain absorbed nine cubic inches of the gas, and hence concludes that 1 of phosphorus combines with 6.8 of oxymuriatic acid, or, agreeably to the nomenclature of this philosopher, who considers the latter a simple body, *chlorine*. The number he gives to represent one proportion of chlorine is 67, that of oxygen being 15 and phosphorus 20; so that he concludes the compound formed by burning phosphorus in chlorine gas to consist of two proportions of chlorine equal 134, to one proportion of phosphorus equal to 20, or $134 + 20 = 154$, the number representing the compound. To this substance he has given the name of phosphorana. The advocates of the old hypothesis consider this compound as constituted by two atoms of muriatic acid, free from water, united to one atom of phosphoric acid, and agreeably to the common nomenclature it will be called a supermuriat of phosphorus. Dalton's number for muriatic acid is 22, for oxygen 7, and for phosphorus 9. Hence this substance will be constituted by $2 \times 22 + 2 \times 7 + 9$, or 58 oxymuriatic acid to 9 of phosphorus, but in fact 44 muriatic acid to 23 phosphoric acid.

The compound in question is described by its discoverer as being a snowy white substance. It is volatile at a temperature less than that of boiling water. It is capable of being fused under pressure, and then crystallizes in the shape of prisms which are transparent.

He states that "it acts violently upon water, which it decomposes." Its phosphorus combines with the oxygen, producing phosphoric acid, and its chlorine with the hydrogen, forming muriatic acid. The advocates for the old opinion equally well explained the action of water upon this substance, by supposing the same quantity of water to combine with the muriatic acid, which sir Humphry would state to be decomposed.

Another compound of this kind has been discovered by the same chemist, by distilling phosphorus through the powder of corrosive sublimate in a glass tube. A limpid fluid is obtained, which he states to be a compound of one proportion of chlorine with one proportion of phosphorus, or $67 + 20 = 87$. The properties of this compound are stated by sir Humphry as follows: it emits and fumes when exposed to the air, decomposing the aqueous vapour, and is converted into acid in the air without inflammation. In its pure state it does not redden dry litmus paper. The vapour from it burns in the flame of a candle. When poured into water, it is converted into muriatic and phosphorous acid, the hydrogen combining with the chlorine to form muriatic acid, and the oxygen with phosphorus forming phosphorous acid. This solution, being evaporated to the consistence of syrup, affords a very pure phosphorous acid combined with water, the muriatic acid having escaped. It becomes solid on cooling.

Sir H. Davy has called the above compound phosphorana.

By those of the common opinion, this substance is considered as a compound of pure muriatic acid and phosphorous acid. The phosphorus, on passing through the superoxymuriat of mercury, took an atom of phosphorus from the mercury forming phosphorous acid, which, combining with an atom of muriatic acid, formed the compound in question, leaving behind an atom of muriat of mercury (calomel), which consists of an atom of muriatic acid, with an atom of the first oxyd of mercury. By Dalton's numbers this substance is constituted by one atom of muriatic acid, 22 added to one of phosphorous acid, equal to $9 + 7$ or 16, the whole being equal to $22 + 16 = 38$. All the phenomena stated above, which have been explained by sir Humphry's hypothesis, will be equally well explained by the old theory. The above ingenious chemist has pointed out a third compound of chlorine with phosphorus, which he supposes to consist of one proportion of chlorine with two of phosphorus, or $67 + 2 \times 20 = 107$. This, by the old doctrine, would be considered as composed of 1 of muriatic acid, 22 to 2 of phosphoric oxyd, equal 32, the whole being 52.

This substance was first obtained by Guy Lussac and Thenard, by distilling phosphorus and calomel. If its constitution be as above stated, 9 of phosphorus should be distilled with 196 of calomel.

Phosphorus combines with hydrogen, forming a gaseous compound called by some phosphoretted hydrogen, and by others more properly phosphoret of hydrogen. Several circumstances shew the affinity between phosphorus and hydrogen to be very slight, particularly its liability to be decomposed even by agitation with water. The following is the process recommended by Dalton for procuring it. To two ounces of dry hydrat of lime, or lime which has just taken as much water as is required to slack it, add 50 grains of phosphorus in small bits. Let these be put into a glass retort, which has been previously filled with nitrogen gas. Without the latter precaution the presence of oxygen would decompose the gas intended to be obtained. Let the neck of the retort be connected with an hydromuriatic trough, and apply the heat of a lamp, which brings over the gas. The lime is here more than is necessary, which is no inconvenience. The absolute quantities which are engaged in the process are, 1 atom of hydrat of lime $= 8 + 24$, and 2 atoms of phosphorus $= 2 \times 9 = 18$. The water of the hydrat of lime is decomposed. The oxygen combines with one atom of phosphorus, forming phosphorous acid, which afterwards combines with the lime. The hydrogen combines with the other atom of phosphorus, forming phosphoret of hydrogen, which comes over in the form of gas. In this state it takes fire spontaneously in the open air, or in contact with oxygen. The phosphorus is easily separated by the electric spark, and even by standing over water, leaving the hydrogen pure, and occupying the original volume of the gas. This latter effect taking place partially, has given rise to the opinion of phosphorus combining with hydrogen in different proportions. We can hence explain the assertion made by sir H. Davy, in which he says he has obtained phosphoretted hydrogen gases of different specific gravities, from 4 to 7; hydrogen being 1.

The composition of this gas is easily inferred from its specific gravity, which Dalton states to be 10.5, hydrogen being 1. Hence if 1 of hydrogen takes up 9.5 of phosphorus without any change of volume, it will make the specific gravity as above. By theory, 9 of phosphorus should combine with 1 of hydrogen, when 1 atom of the former combines with 1 of the latter. We may hence conclude that an atom of this gas in a state of purity is $1 + 9 = 10$.

To confirm this, Mr. Dalton found that 1 measure of this gas to 1.5 oxygen produced phosphoric acid; and 1 measure to 1 produces phosphorous acid. We are indebted to sir Humphry Davy for the discovery of a new compound of phosphorus and hydrogen, which he obtained by exposing the solid hydrat of phosphorous acid to heat in a retort. An elastic fluid is produced, having a less disagreeable smell than the phosphoret of hydrogen, already described. It does not, like the latter, explode spontaneously. When heated to 300° Fahrenheit with oxygen, it detonates with

violence. It alſo explodes in oxymuriatic gas with a white flame. This chemiſt ſuppoſes its ſpecific gravity to be about 12, hydrogen being 1.

When heated in potaſſium, its volume is doubled, and the gas produced is pure hydrogen. When ſulphur is ſublimed in it, the volume is doubled, and ſulphuretted hydrogen gas produced.

He found that 3 in volume of this gas took up more than 5 of oxygen. He concludes its compoſition to be nearly 2 of hydrogen to 10 of phoſphorus, by weight. According to Dalton's numbers it will conſiſt of an atom of phoſphorus to 2 of hydrogen, or $9 + 2 = 11$. If its volume be doubled by taking away its phoſphorus, which is the caſe in the experiment with potaſſium, its ſpecific gravity will be increaſed by 1 compreſſed into $\frac{1}{2}$, which will give ſpecific gravity equal to 2: this added to 9, the weight of the phoſphorus, will give $9 + 2 = 11$, which is very near to ſir Humphry's experiment. In the experiment where it combines with the ſublimed ſulphur, the volume is doubled, and two atoms of ſulphuretted hydrogen are formed, one of which being equal to the original volume, will make the ſpecific gravity of this gas equal to that of ſulphuretted hydrogen, which is about 14, hydrogen being 1. The mean of theſe will be $\frac{11 + 14}{2} = 12.5$, which comes very near to ſir Humphry's ſtatement of the ſpecific gravity, and ſtrongly confirms the reſt of the facts relative to it.

The oxygen required for its total abſorption will be 28 to 11 by weight, and $\frac{28}{11} \times \frac{12}{14} = \frac{24}{11}$, or 2 to 1 by meaſure nearly. This is obtained by multiplying their ratios of weight by the inverted ratio of their ſpecific gravities.

Phoſphorus combines with ſulphur by melting them together in a glaſs tube, from which oxygen is excluded. The compound is more fuſible than either of the elements. Sir Humphry Davy found that a compound of theſe bodies in the proportion of 3 of ſulphur to 4 of phoſphorus, is fuſible at 40° Fahrenheit. When ſolid, its colour was of a yellowiſh-white. Theſe bodies, like all others, muſt produce moſt complete compounds in certain definite proportions dependent on the ratio of the weight of their ultimate atoms. Atom to atom, their proportions will be 9 to 13. The compound above alluded to will be 2 atoms of phoſphorus to 1 of ſulphur, or $18 + 13 = 31$. The moſt remarkable properties poſſeſſed by theſe compounds are their increaſed fuſibility, and their taking fire at a lower temperature than phoſphorus. This latter property has been taken advantage of in making the common fire-bottles. Their proportions for this purpoſe are generally about 2 phoſphorus and 1 ſulphur. This is nearly 3 atoms of phoſphorus to 1 of ſulphur, which would be 3×9 to $13 = 27$ to 13.

Dr. Prieſtley has made many experiments with phoſphorus, in different kinds of air; and has found, that it ſmoked and gave light in the acid air, juſt as it would have done in common air confined, without being ſenſibly waſted for twelve hours, and with a very inconſiderable diminution of the bulk of the air; in alkaline air it gave no light and made no laſting change in its dimenſions; in nitrous air, it gave no light, nor did it leſſen its power by diminiſhing common air, and the phoſphorus remained unchanged; and after having remained a day and two nights in vitriolic acid air, it produced no ſenſible effect, and gave no light.

Dr. Fordyce has ſuggeſted the following eaſy method of reducing phoſphorus to powder: take phoſphorus of urine two drachms; put it into a four-ounce phial; pour upon it three ounces of water; heat it gently by immerſion in warm water, till the phoſphorus melts; ſhut the phial with a cork; take it out of the water, and ſhake it briſkly till it be cold; and the phoſphorus will be found in powder. A receiver may be lined with this powder by adding a very ſmall quantity of water to it, and then making the powder to adhere to its internal ſurface, by gently inclining and turning the receiver round. Macquer's Chem. Dict. art. *Phoſphorus*, and Prieſtley's Experiments and Obſervations on Air, &c. Phil. Tranſ. vol. lxi. part ii. p. 504, &c.

PHOSPHORUS, *Properties of Solid.* 1. With this phoſphorus one may write on paper as with a pencil, and the letters will appear like flame in the dark; yet, in the light, nothing will appear but a dim ſmoke. This is occaſioned by the oxygen of the atmoſphere combining ſlowly with the phoſphorus.

If the letters written with this phoſphorus are warmed by the fire, they preſently become dark lines, which continue upon the paper like ink.

2. A little piece, rubbed between two papers, takes fire inſtantaneouſly, and if care be not taken in the management of it, there is danger of burning the fingers, the phoſphorus being exceedingly inflammable.

3. Its burning is very vehement, and penetrates deeper into the fleſh than common fire; and it is very difficult to be extinguiſhed.

Dr. Slare, in order to determine whether air contains the pabulum of flame, as ſome have ſuppoſed, placed a large piece of phoſphorus in a receiver; but upon exhauſting it, he found that it became more luminous, and that upon admitting the air it returned to its former ſtate. This property was alſo aſcertained by ſeveral experiments of Mr. Hauksbee.

M. Caſſini happening to preſs a piece in a cloth between his fingers, the cloth immediately took fire; he endeavoured to put it out with his foot; but his ſhoe caught the flame, and he was obliged to extinguiſh it with a braſs ruler, which caſt forth rays in the dark for two months after.

The ſolid phoſphorus ceaſes to ſhine and never ſpoils, provided it be kept in a phial full of water; but if any part of it emerge, it will ſhine, though the glaſs be hermetically ſealed; and will continue ſhining in a large glaſs without water for ſeveral days, with very little diminution of its light or weight; and even when immerſed in water, it will ſometimes make very bright and vigorous corruſcations in the air; that in form of an unguent, does not keep ſo well; and the liquid phoſphorus worſt of all.

The liquid phoſphorus is beſt made by digeſting in horſedung, a little bit, or ſome ſcrapings of the ſolid kind, for two days, in oil or eſſence of cloves, oil of turpentine, or the like. After the diſſolution, the oil will be ſo impregnated with it, that, upon opening the bottle, the matter will appear on a flame.

PHOSPHORUS, *Experiments with Liquid.* By waſhing the face, hands, or the like, with liquid phoſphorus, Dr. Slare tells us they will be made to ſhine very conſiderably in the dark, and the luſtre thereof will be communicated to adjacent objects, yet without any offence to the ſkin.

As ſoon as the candle is brought in, the ſhining diſappears, and no change is perceiveable.

This phoſphorus emits frequent flaſhes like lightning, even when cloſe ſtopped, eſpecially in warm water. Hence Mr. Boyle takes occaſion to draw a parallel between lightning and phoſphorus. Phil. Tranſ. Abr. vol. iii. p. 348, &c. Hauksbee's Phyſico Mech. Exper. p. 122. In ſome caſes animal ſweat, which is ſimilar to urine, has been obſerved to be phoſphoraceous, without any preparation. An inſtance of this kind is related of a perſon who uſed to eat great quantities of ſalt, and who was a little ſubject to the gout, after ſweating with violent exerciſe. Stripping himſelf in

the dark, his ſhirt ſeemed to be on fire, and a urinous ſmell was perceived, ſimilar to that which iſſues from cabbage much ſalted and ſtrongly fermenting. Act. Cæſarienſia, vol. v. p. 334.

PHOSPHORUS, *Bolognian*, or *Bononian*. The ſecond kind of artificial phoſphorus, is a preparation of ſtone called the Bononian ſtone, from Bologna, a city in Italy, near which it is found.

The firſt who undertook to make this ſtone luminous, was a chemiſt of that city, called Vicenzo Caſciarolo. Poterus, Licetus, &c. have deſcribed the proceſs; but miſtakenly. M. Homberg, who made a journey to Italy, expreſsly to learn the preparation, firſt communicated the ſame to M. Lemery, who publiſhed it in the ſeventh edition of his chemiſtry. (See BONONIAN *Stone*.) Under that article, the reader will find ſome account of the diſcovery of this ſtone, and of the method of preparing it. We ſhall here ſubjoin ſome farther particulars on this ſubject, chiefly extracted from the diſſertations of M. Margraaf. The Bolognian ſtone, he ſays, is ſoft, friable, heavy, cryſtallized, and incapable of efferveſcing with acids, before it has been calcined in contact with fuel, and with a free acceſs of air. Theſe qualities have induced him to claſs it among the heavy fuſible ſpars, which, by a preparation ſimilar to that for the Bolognian ſtone, are rendered phoſphoric. After analyſing theſe ſubſtances, he concludes that all contain a vitriolic acid, united to an alkaline or calcareous earth. In order to render theſe ſtones phoſphoric, ſuch of them ought to be choſen as are the cleareſt, but cryſtallized, moſt friable, moſt heavy, which exfoliate when broken, and which contain no heterogeneous parts. They are to be made red-hot in a crucible, and reduced to a very fine powder in a glaſs mortar, or upon a porphyry, and not in a copper mortar, which will obſtruct the ſucceſs of the operation. The powder thus obtained, is to be formed into a paſte with gum tragacanth, and divided into cakes as thin as a knife. Theſe are to be dried by a gradual heat. An ordinary reverberatory furnace is to be filled to three quarters of its height with charcoal, and the fire to be kindled; upon this charcoal the flat ſurfaces of the cakes are to reſt; and more charcoal is to be placed above them, ſo as to fill the furnace, which is then to be covered with its dome, the tube remaining open: all the coal is to be conſumed, and the furnace left to cool. The cakes are then calcined, and are to be cleanſed from the aſhes by blowing upon them with bellows. He farther obſerves, that after this calcination through the coals, if the ſtones be expoſed to a ſtronger calcination during a full half hour under a muffle, their phoſphoric quality will be rendered ſtronger. Ac. Berlin, 1749, and 1750.

This phoſphorus has not any ſenſible heat, and only becomes luminous after being expoſed to the ſun, or the daylight; in which ſtate it reſembles a burning coal, and preſerves its light five or ſix minutes in the dark, eſpecially if the perſon obſerving it has been ſome time in the dark, or has ſhut his eyes, that the pupils may be ſufficiently expanded; during which time the light gradually dwindles; and, to recover the ſhining, it muſt be expoſed afreſh to the light.

PHOSPHORUS, *the Hermetic*, or *Phoſphorus Balduini*, which makes the third kind, and properly belonging to the ſame claſs with the former, is a preparation of Engliſh chalk, with aquafortis, or ſpirit of nitre, by the fire. See BALDWIN'S *Phoſphorus*.

This makes a body conſiderably ſofter than the Bolognian ſtone; but it has all the qualities of it. It has its name from its inventor Baldwin, a German chemiſt, called *Hermes*, in the ſociety of the Naturæ Curioſorum; whence its other name *Hermetic*. It was diſcovered a little before the year 1677.

This phoſphorus of Baldwin is exactly ſimilar to thoſe made with Bolognian ſtone and phoſphoric ſpars, differing only in the kind of acid which it contains. It is evidently a nitre with a calcareous baſis, and in calcination acquires its phlogiſton from the nitrous acid, the chalk alſo containing ſome of this inflammable principle. It is obſerved, however, that this is not ſo good a phoſphorus as the Bolognian; it is not ſo luminous, it does not retain the light ſo long, it ſoon loſes its virtue, and never recovers it again. Acad. Par. 1693, p. 271.

The proceſs for making this phoſphorus, though Baldwin gave no direction for it, nor ſo much as mentioned the materials, was communicated to the Royal Society, in 1679, by Dr. Slare, and publiſhed by Grew, in his Muſ. Reg. Soc. p. 353; and is as follows: Take good firm chalk, ignite it in a crucible, and then powder it; put into a pint, or half a pint of ſtrong ſpirit of nitre, *cochleatim*, as much of the powdered chalk as will ſerve well to ſatiate it, *i. e.* till it becomes ſweetiſh, and makes no efferveſcence upon the injection of the chalk. Then dilute this liquor with fair water, filtre it through a paper, and ſo evaporate it in a large glaſs, or glazed veſſel, or good Heſſian crucible, to a dry ſalt. The preparation may be performed in four hours.

To this claſs we may alſo refer ſome other phoſphori, enumerated in the ſequel of this article. As the

PHOSPHORUS, *Ammoniacal*, compoſed of ſal ammoniac and lime, which Mr. Homberg firſt diſcovered.

The method of preparing it is this: Take one part of ſal ammoniac in powder, and two parts of lime extinguiſhed by lying in the air: mix them exactly together and fill a crucible with the mixture; ſet it in a ſmall melting heat. As ſoon as the crucible grows red-hot, the matter in it will melt, and it muſt be ſtirred with an iron rod, leſt it ſwell over the edges of the crucible: as ſoon as the whole is melted, pour it into a copper baſon; it will appear of a greyiſh colour and vitrified, and if it be ſtruck upon with any hard body, there will be ſeen a fire all over the place where the blow was given. As this matter is brittle, however, and the ſame maſs will not ſerve often for the experiment, the beſt method is to dip iron rods in it while melting, and theſe will be covered with the matter, and will anſwer the purpoſe eaſily and often. Mem. Acad. Par. 1693.

This is a combination of quick-lime with the acid of ſal ammoniac.

PHOSPHORUS, *Antimonial*, is the name of a ſubſtance having the qualities of the phoſphorus diſcovered by Mr. Geoffroy, in his experiments on antimony. This gentleman had prepared a ſoap from pot-aſhes, quick-lime, and oil, with which he made ſeveral experiments on antimony; among others, he was deſirous, by means of this, to reduce ſome diaphoretic antimony, which he had before made from two parts of the regulus of antimony, and three parts of nitre; but, inſtead of the reduction which he was labouring after, his operation afforded him a much more ſingular phenomenon: the reſult of them being a phoſphorus, which he had never thought of; a matter which, after having remained perfectly quiet while cloſe ſtopt down, took fire as ſoon as ever it was expoſed to the air; and that with a violent detonation, and darting every where a ſhower of fire.

It is eaſy to ſee, that there are in the preparation all the requiſites for ſuch an effect; nitre, charcoal furniſhed by the burnt ſoap, and ſulphur both from the ſoap and from the regulus of antimony; and to all theſe a ſort of calx,

either from the foap, or from fome earthy parts of the antimony. It is eafy to conceive, that all thefe fubftances, coming into a mixture together, fhould be ready to catch fire and blaze, upon a proper application; but it is not lefs difficult to account for the effects being produced merely by the air, after the whole had been for a long time in a ftate of reft.

The method of preparing this new fpecies of phofphorus is this: Mr. Geoffroy mixed two ounces of his foap with one ounce of this diaphoretic antimony; this mixture, being put by little and little into a red-hot crucible, took fire, and fwelled very much; after it had done flaming, the mafs fubfided, and became a red or fire-coloured fubftance, of an even furface, but ftill throwing up a vaft quantity of blueifh-green luminous vapours; and all this regularly happened on every frefh throwing in of the matter, without the leaft variety. When the whole quantity was thrown in, and had ceafed to give any flame or luminous vapour, it remained in the crucible in the form of an inverted mufhroom, being hollow, very porous, and of a black colour. When the crucible was taken out of the fire, the edges of this fubftance were beaten down into the middle, and the whole covered with an ounce of frefh foap; when this laft foap was burnt, and a fmall blueifh flame appeared upon the furface of the mafs, the crucible was covered with a lid, and a large quantity of charcoal laid upon it, and the fire blowed up very brifkly by an hundred blafts of the bellows, or thereabouts; but, notwithftanding the fiercenefs of the fire, there was no fluid fcoria formed, but the whole mafs remained fpungy and porous; the fire was then fuffered to go out, and the crucible placed in the corner of the elaboratory at reft for five hours. In the evening, when the crucible was perfectly cold, Mr. Geoffroy went to examine the matter, and a fervant went to uncover the mafs, by removing its furface with an iron inftrument; but the moment the air was admitted, the whole mafs took fire, burning with a very confiderable noife, and darting its flames every way to a great diftance.

Mr. Geoffroy repeated the procefs feveral times, and always with the fame fuccefs, whether he ufed his own diaphoretic antimony, or that made in the common manner. The great caution to infure the fuccefs, feems to be taking care of not carrying the fire too far before the addition of the laft quantity of foap. Mem. Acad. Scien. Par. 1736.

PHOSPHORUS *of the Bern-ftone*, is a name given to ftone (which, when heated, becomes a fort of phofphorus) from Bern, in Switzerland, the place where it is found.

This fubftance was fent to the members of the Royal Academy at Paris, by M. Bourguet, and referred by them to the examination of M. du Fay, whofe account of it is publifhed in Mem. Acad. Paris, 1724.

The Bern-ftone is of a moderate hardnefs, confiderably pellucid, and ufually colourlefs, or whitifh, though fometimes with a tinge of green, yellow, or fome other colours: it is compofed of a number of plates or flakes, laid over one another in the manner of the ifland cryftal; and, therefore, like that body is plainly a fpar. It breaks into feveral faces, and has different angles; but of a fomewhat determinate meafure, the acute ones being of fixty degrees, and the obtufe ones of one hundred and twenty.

This ftone, when heated at one of its angles with the flame of a lamp or candle, fplits by means of the flame's infinuating itfelf into the interftices of the plates that are lefs firmly united; and thefe feparate, and fome fragments ufually fly off with confiderable violence. One of thefe pieces, carried into an obfcure place, appears furrounded with a blue flame, which lafts about a minute. And it is to be obferved, that thefe pieces which fly off have all the fhape of an irregular pyramid, with an uneven bafe. If this ftone be put into a crucible and furrounded with coals, it becomes a very beautiful phofphorus. The whole bottom of the crucible is feen, even though it be in broad day-light, fhining with a bright and beautiful blueifh white; and if it be carried into a dark place, the light is feen much more beautifully. If, after it is cold, it be again heated in a crucible, in the fame manner, it fhews the fame bright appearance. After this, if it be tried a third time, it does not fhine at all. According to all thefe phenomena, the effects of fire upon this ftone feem to depend on a fulphur contained in it, probably of the fame nature with that which enters the compofition of the metals. This may, by means of a heat, fuch as that given by the candle or in the crucible, difengage itfelf fo far from the body of the ftone as to take fire; and when it has burnt fo long as to confume itfelf, the luminous property of the ftone feems to ceafe.

The coloured gems are cryftals of a peculiar kind, tinged with what has been called the fulphur or phlogifton of metals: this fulphur gives them their colour, and confequently it ought to give them the properties of the Bern-ftone, if it were not too fixed to be diffipated in the fame eafy manner, and to take fire in the diffipation. And it appears, on trial, that the baftard emeralds of Auvergne and other places, the matrix of the amethyft, the fragments of fome of the accidental jafpers, the hyacinths, and fome fort of rubies, are all phofphorufes of the nature of the Bern-ftone, but with different degrees of brightnefs. The mother of the emerald, the yellow jafper, the water fapphire, the malachite, the opal, and the garnet, have none of them any of this property.

Since the fame fulphurs, which take fire in the Bern-ftone, are what give colour to thefe other ftones, it fhould feem, that thofe, which are not of this phofphorus kind, nor give a light after being heated, fhould not lofe their colours in the fire; and this is found to be true in the garnet, which does not lofe any part of its colour, nor is it at all luminous; whereas the hyacinth, and fome of the jafpers and other ftones, which lofe a part of their colour, not the whole, in the fire, become alfo in part luminous, or more fo, in degree, according to the quantity of colour which they lofe. This, however, is no certain rule, fince the mother of the emerald, the topaz, and fome other ftones, lofe all their colour, and yet are not at all luminous. The reafon of this feems to be, that the fulphurs are driven out of thefe ftones fo flowly, and in fuch minute quantities, that they are not at any time collected into body enough to be capable of flame. There is nothing to be objected as to the Bern-ftone fhining; though they are ufually white, they may poffefs no fmaller portion of fulphurs than the coloured ftones; only in thofe the fulphurs may be colourlefs, or white in themfelves. It may be poffible alfo, that the fulphurs in a ftone of this kind may be difperfed in fuch fmall molecules, as not to form a body fufficient to give any colour; but when collected, in order to be driven off in the fire, they may then be fufficient in quantity to give a blue tinge to the flame.

The ifland cryftal, which is alfo a fpecies of fpar, and which greatly refembles this Bern-ftone in many particulars, flies to pieces alfo in the fame manner, on being heated; and when carried into the dark, this alfo gives fome fparks of light, but they are few in number, and loofely fcattered over the furface: when this ftone is burnt a little in the crucible, there is fome fmall appearance of flame, with a

ſmell of ſulphur, and the matter in the bottom of the crucible is found ſhattered to pieces; but all the pieces are regular parallelopipeds, as was the original maſs.

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Pier

PIER, in *Building*, derived from the French *pierre, a ſtone*, denotes a maſs of ſtone, &c. oppoſed, by way of fortreſs, againſt the force of the ſea, or a great river, for the ſecurity of ſhips that lie at harbour in any haven, ſuch are the pier of Dover, deſcribed by Camden Brit. &c., the pier of Ramſgate, and the haven pier of Great Yarmouth, mentioned 22 Car. II.

PIERS are alſo uſed in *Architecture* for a kind of pilaſters, or buttreſſes, raiſed for ſupport, ſtrength, and ſometimes for ornament.

PIERS, *Circular*, are called *maſſive columns*, and they are with or without caps, and are frequently ſeen in Saracenic architecture.

PIERS *of a Bridge*. See BRIDGE.

M. Belidor obſerves that, when the height of the piers is about ſix feet, and the arches are circular, it is ſufficient to make their thickneſs the ſixth part of the width of the arch, and two feet more; but when the arches become of a great ſpan, the thickneſs of the piers may be reduced to the ſixth part; but then the depreſſion of the two feet doth not take place at once; that is, in an arch of above forty-eight feet, three inches are taken off for every ſix feet of increaſe of the width of the arch. The thickneſs of the piers ſupporting elliptic arches is greater than in the former proportion: thus, in an arch of ſeventy-five feet wide, the thickneſs of the pier, whoſe height is about ſix feet, ſhould be 13.5 when the arch is circular, and fifteen feet when it is elliptical.

The ſame author makes the abutments one-ſixth part more than the piers of the largeſt arch.

Mr. Muller has calculated the following table, containing the thickneſs of the piers of bridges.

TABLE containing the Thickneſs of the Piers of Bridges.

	6	9	12	15	18	21	24
20	4.574	4.918	5.165	5.350	5.492	5.610	5.698
25	5.490	5.913	6.216	6.445	6.645	6.801	7.930
30	6.386	6.816	7.225	7.513	7.746	7.939	8.102
35	7.258	7.786	8.200	8.532	8.807	9.037	9.233
40	8.404	8.691	9.148	9.523	9.835	10.101	10.328
45	8.965	9.579	10.077	10.489	10.837	11.136	11.394
50	9.805	10.454	10.987	11.435	11.817	12.146	12.434
55	10.640	11.245	11.882	12.364	13.019	13.149	13.218
60	11.400	12.110	12.718	13.281	13.723	14.109	14.314
65	12.265	13.025	13.648	14.185	14.654	15.082	15.433
70	13.114	13.869	14.517	14.049	15.573	16.011	16.400
75	14.000	14.705	15.336	15.965	16.480	16.940	17.354
80	14.747	15.542	16.234	r6.842	17.381	17.864	18.298
85	15.513	16.328	17.041	17.674	18.237	18.742	19.194
90	16.373	17.102	17.929	18.578	19.157	19.679	20.152
95	17.184	17.826	18.772	19.438	20.036	20.577	21.068
100	17.991	18.848	19.610	20.293	20.908	21.466	21.976

The firſt horizontal line expreſſes the height of the piers in feet, from 6 to 24 feet, each increaſing by 3: the firſt vertical column, the width of arches from 20 to 100 feet, for every 5 feet.

The other columns expreſs the thickneſs of piers in feet and decimals, according to the reſpective height at the head of the column, and the width of the arch againſt it in the firſt column.

Rectangular piers are ſeldom uſed but in bridges over ſmall rivers; in all others they project from the bridge by a triangular priſm, which preſents an edge to the ſtream, in order to divide the water more eaſily, to prevent the ice from ſheltering there, as well as veſſels from running foul againſt them. This edge is terminated by the adjacent ſurfaces at right angles to each other at Weſtminſter bridge; but thoſe of the Pont-royal, at Paris, make an acute angle of about 60°. However the French, in their later conſtructions, make this angle to terminate by two cylindric ſurfaces, whoſe baſes are arcs of 60 degrees. Muller's Pract. Fortif. part iv. ſect. 1. p. 257. &c.

Piles

PILES, in *Hydraulic Architecture*, are beams of timber, or ftakes of wood, driven firmly into the ground, for various purpofes; as, for forming a firft foundation for buildings, piers of bridges, &c.; in which cafes they are driven quite down into the ground, or are cut off level with its furface, with a view of obtaining a folid bearing for the weight of the ftructure which is to be raifed.

Amfterdam, and fome other cities, are wholly built upon piles. The ftoppage of the breach in the banks of the Thames at Dagenham, was effected by dove-tail piles; that is, by piles mortifed into one another by a dove-tail joint.

Piles are not employed for foundations unlefs the ground is fufpected to be unfound, or when the weight to be borne is exceedingly great. They act to make the foundation folid, by reaching deep into the earth, down to a more fubftantial ftratum, than that of the furface. Indeed, the manner of fixing the piles, by driving them by repeated blows of a powerful machine till they will go no farther, enfures that they come to a good bearing. There are inftances of piles being driven down twenty-five feet, before they were thought fufficiently firm.

Piles are alfo ufed for making the faces of wharfs, banks of rivers, piers for the fea, &c. For thefe purpofes they are driven in rows, but only a fufficient depth in the earth to make them ftand firm, and fupport the planking or framing which is fixed againft them. Thefe piles are ufually driven rather in an inclined pofition. For temporary defence againft the water, in laying the foundation of bridges, &c. piles are always required. They are employed in different ways to form an enclofure, or water-tight wall, called a coffer-dam, round the area where the work is to be laid, and from which fpace the water is drawn by pumps. This is the moft difficult of all kinds of piling; becaufe it muft ftand a great height above the ground, have fufficient ftrength to refift the preffure of water, and be perfectly clofe and tight. In navigable rivers detached piles are driven, and very firmly fixed, to mark the enclofures where barges are to lay, and to fender off others from them, as well as to moor them to.

Piles are in general formed of a fquare timber, tapering if the tree happens to be fo, cut to a fharp point at one end, and fhod with iron to enter the ground. The other end was bound by a ftrong iron hoop, to prevent the pile head fplitting by the violence of the blows which drive it down. When they are to be driven quite below ground, fmall trees, if fufficiently ftraight, may be ufed without fquaring; but for coffer-dams fquare piles are always ufed, except that for filling up a row between fuch fquare piles. When they are to touch each other, flat ones, called pile planks, are ufed; they are three or four inches thick, according to the depth of water, and have grooves formed in their adjacent edges, to receive tongues or flips of wood, which make the joints quite tight. To enclofe an area for a coffer-dam, two rows or walls of piles are ufually driven one within the other, at a diftance ufually equal to the depth of water they are driven in, or if the current is rapid, once and a half. The fpace between thefe is filled with clay, fo as to form a mound or rampart of clay, defended on the outfide and infide by wooden walls of piles. To make thefe walls, large fquare piles are firft driven at a diftance of ten or twelve feet afunder, in the line of the intended range of the dam; horizontal tye beams are then extended from one pile to the next, on the infide, each tye being notched into the piles, fo that its outer edge is in a line with the infide of the groove for the plank piles, which are to be driven down to fill up the fpaces between the piles, and will be guided by thefe tyes to ftand exactly vertical, and in a ftraight line. The firft plank piles are begun to be fixed adjacent to the main piles, and thus they proceed from both ends of the fpace between the piles, till the planks meet in the centre, where the laft plank is inferted, and being formed rather wedge-like, makes all the reft tight. The pile planks are cut inclined, or wedge-like on one fide only, to form the point, by which means the point is the line of one of the edges of the plank. When a plank pile is to be driven adjacent to another, this edge is applied to the one already fixed, and then as it is driven, the inclined or wedge-like edge entering the ground, caufes the pile to approach, and prefs very clofe to its neighbour, and it is chiefly by this means they are made to fit water-tight. The fillets are made by fpiking a ledge or ruler of wood faft upon the edge of one plank, and a groove of correfponding depth and width is ploughed in the edge of the adjacent plank to receive it. Many different machines are ufed to drive piles into the ground; fome of them are worked by a great number of men, who raife a heavy weight a fmall height, and let it fall upon the pile, till, by reiterated blows, they drive it to the required depth. The machine employed is extremely fimple. A long thick plank of wood is fixed up clofe to the pile, having a mortife through the upper end, in which a pulley is fitted; a rope goes over this to fufpend the rammer, which is a large block of hard wood, properly hooped, to prevent it from fplitting. In rifing and falling, it flides againft the face of the plank, and is guided by irons, which are fixed to the ram, and are bent round the edges of the plank in the manner of hooks. The plank, when placed upright, is fecured by guy ropes, in the manner of the maft of a fhip; the end of the great rope which fufpends the ram, has ten or twelve fmall ropes fpliced into it, for as many men to take hold, and work it by; they raife the ram up two or three feet by pulling the ropes all together, and then letting them go, the ram falls upon the pile head. When the pile becomes firm enough to caufe the ram to rebound, they take care to pull the ropes inftantly after the blow, that they may avail themfelves of the leap it makes.

This is the fimpleft form of the machine. Others, inftead of a plank, have two upright beams attached together, at fuch a diftance afunder, as to leave an opening between them, for the reception of a piece of wood which is affixed to the ram, and by this means it is guided. Inftead of guy ropes,

these are usually fixed upon a base, consisting of a triangular frame, upon one angle of which the uprights are erected; and from the other two angles, braces arise, which are so inclined as to reach the uprights at half or two-thirds of their height to steady them. This plan is very convenient for driving piles in corners; but for driving rows, it is more advantageous to have the uprights fixed at the middle of one side of the triangular base, and have stays from all the three angles. A machine of this kind, with a ram of beech four feet long and one foot square, may be worked by ten or twelve men, at the rate of twenty-four blows *per* minute, and fixes the pile very quickly.

To estimate the force of the rammer made use of to drive piles, its weight ought to be multiplied into the velocity it acquires in falling. Thus, if a rammer which weighs 500lb. be let fall from four feet, it will fall that height in half a second, and have at the time of percussion a velocity capable to carry it uniformly eight feet in half a second, without any farther help from gravity; so that we must multiply 500 by 16, or its weight by the number of feet it would fall in a second, and the product 8000 gives the momentum of the stroke. If a capstan, pullies, or windlass, be made to raise the rammer to a considerable height, and then, by an easy contrivance, loosen it at once from its hook, the momentum of the stroke will always be as the square root of the height from which the rammer fell.

Notwithstanding the momentum, or force of a body in motion, is as the weight multiplied by the velocity, or simply as its velocity, when the weight is given or constant; yet the effect of the blow will be nearly as the square of that velocity; the effect being the quantity the pile is driven into the ground by the stroke. For the force of the blow, which is transferred to the pile, being destroyed in some certain definite time by the friction of the part which is within the earth, which is nearly a constant quantity, and the spaces in constant forces being as the squares of the velocities; therefore, the effects which are those spaces sunk, are nearly as the square of the velocities, or, which is the same thing, nearly as the heights fallen by the ram or hammer to the head of the pile. See upon this subject Leopold, Belidor, also Desaguliers's Exper. Philos. vol. i. p. 336, and vol. ii. p. 417, and Philos. Trans. 1779, p. 120.

For large works, such as bridges, &c., the piles are driven by a different kind of machine: this has a very heavy iron ram, with mechanical powers, by which it is raised to a considerable height, and then let fall, instead of continually repeating small blows. These are sometimes worked by horses, or steam-engines: see elevations of one, in *figs.* 1. and 2, *Plate* XXXV. *Mechanics.* A, A, are the uprights, erected on the frame B, and supported by the braces C; they are connected by the cross feet *a* at bottom, and the piece D at top; in this the pulley *b* for the rope *d* is fitted. Fillets of iron are fixed withinside the uprights A, A, and enter grooves made in the edges of the great iron ram E, which is thereby guided as it rises and falls: F is a piece, called the follower, (see *figs.* 3 and 4.); it is a wooden block, sliding between the uprights, and mortised to receive the iron tongs *e*, which take hold of an eye upon the top of the cast iron ram: the rope is attached to the follower by an iron loop *f*, through which the centre pin of the tongs passes. On the base, *a* B, of the machine an iron frame is bolted, to contain the windlass G, on which the rope *d* winds. On the end of the windlass a cog-wheel, *g*, is fixed, and a pinion upon the axis, *h*, engages its teeth. Motion is given to the spindle *h* by the winches *k*, fixed on each end of it, and the fly-wheel, *l*, regulates its motion, when turned by two men at each handle. The pile is of course included in the space between the two uprights, A, A, before it is driven down; and the ram, being engaged by the tongs *e*, is drawn up by turning the handle, *k*, till the tails, *n*, of the tongs come to the inclined planes *m*, *fig.* 1: by these they are closed together, which opens the lower ends, disengages them from the eye of the ram, and it falls upon the head of the pile immediately. The men at the handles shift the spindle *h* endways, which disunites the pinion from the wheel, and then the weight of the follower, F, runs back the windlass G, and descends till its tongs take hold of the ram, ready to take it up again. The inclined planes, *m*, are not fixed to the uprights A, A, but are connected together by pieces of wood, which embrace the uprights, and these have holes through them to receive iron bolts, which also pass through the uprights. By this means the inclined planes can be shifted, to set them at any required height, that they may, by discharging the ram at the proper height, give a blow proportioned to the pile which is to be driven by it. The tongs are sometimes made with rollers in the ends *n*, *n*, as shewn in *fig.* 12, that they may act more easily in the inclined planes. Other machines have a kind of latch, shewn in *fig.* 11, instead of the tongs; in this *f* represents the iron loop for the rope; the centre pin of it passes through the latch *r s t*, which catches the eye of the ram by the hook *t*, and is discharged by the line *r*, when the men snatch it. The weight *s* is to cause the hook to catch; the loop *f* is attached to a wooden follower, which guides it between the uprights.

Machines of this kind are frequently actuated by steam-engines. A pulley, which is fixed on the end of the spindle *h*, in place of the handle *k*, receives an endless rope from some wheel put in motion by the engine; one man then attends it, to throw the spindle endways at the proper time, to permit the descent of the follower; but we have seen one in which levers, and a connecting rod from the inclined plane, *m*, were used to disengage the spindle the moment after the follower discharges the ram; by adopting these means much expence of labour would be saved, as the same steam-engine which is afterwards to be employed in pumping out the water of the coffer-dams, would drive the piles for them and the foundations.

The piles of the works of Westminster-bridge, whilst it was building, were driven by a horse-machine invented by Mr. Valoue. A pair of the uprights, such as represented at *figs.* 1 and 2, but thirty feet high, were erected at one end of a frame, which supported a vertical shaft, turned round by the horses, and the framing was of course large enough to admit a circular walk of sufficient size for them to work in, when they drew the ends of arms or levers projecting from the vertical shaft. The whole was erected upon a platform, which was built over a barge in the manner of a deck. The vertical shaft had a wheel or drum upon it, to wind up the rope of the follower, and it was in the construction of this part that the invention lay. A section of the upper part of the vertical shaft and drum is given in *fig.* 8, and a plan in *fig.* 9. Here A is the great upright shaft, or axle, turned by the horses attached to the levers, which are not shewn. The cog-wheel, B, turns the pinion X, having a fly, O, at the top to regulate the motion, and to act against the horses, and keep them from falling, when the heavy ram is disengaged to drive the pile down into the earth in the bottom of the river. The drum, C, is loose upon the axle of the shaft A, but is locked to the wheel, B, by the bolt Y. On this drum the great rope, H, is wound, one end of it being fixed to the drum, and the other to the follower, passing over proper pulleys. In the follower are contained the tongs, which take hold of the ram, by the staple for drawing it up, in the same manner as described in *fig.* 2;

D is a ſpiral, or fuſee fixed to the drum C, on which winds the ſmall rope T: it goes over a pulley, and has a ſmall counterpoiſe hung to the end of it, which hinders the follower from accelerating as it goes down to take hold of the ram; for as the follower tends to acquire velocity in its deſcent, the line, T, winds downwards upon the fuſee on a larger and larger radius, by which means the counterpoiſe acts ſtronger and ſtronger againſt it; and ſo allows it to come down with only a moderate and uniform velocity. The bolt, Y, locks the drum to the great wheel, being puſhed upwards by the ſmall lever 3, which paſſes through a mortiſe on the ſhaft A, and turns upon a pin; the lower end of the bolt is guided by paſſing through a piece of wood, 6, fixed into the great ſhaft, and the upper paſſes through an arm of the wheel; the lever, 3, has a weight, 4, which always tends to puſh up the bolt, Y, through the wheel into the drum; G L is the great lever, turning on the centre *m*, and reſting its end, G, upon the forcing bar 5, which goes down through a hollow in the ſhaft A, and bears upon the little lever 3. The other end of the lever, L, is long enough to reach to the uprights, and has there a ſmall rope, extended from the end of it up to the inclined planes, ſo that the follower, when drawn up to the higheſt, draws this rope, and raiſes the long end, L, of the lever, depreſſing the other, and the forcing bar 5. By the horſes going round, the great rope, H, is wound about the drum C, and the ram is drawn up by the tongs in the follower, till they come between the inclined planes, which, by ſhutting the tongs at the top, open them below, and ſo diſcharge the ram, which falls down between the uprights upon the pile, and drives it by a few ſtrokes as far into the ground as it can go, or as is deſired; after which the top part is ſawed off cloſe to the mud, by an engine for that purpoſe. Immediately after the ram is diſcharged, a piece upon the follower takes hold of the rope, which raiſes the end, L, of the lever L G, and cauſe its end, G, to deſcend, and preſs down the forcing-bar, 5, upon the little lever, 3, which by drawing down the bolt Y, unlocks the drum, C, from the great wheel B; and then the follower being at liberty, comes down by its own weight to the ram; and the lower ends of the tongs ſlip over the eye of the ram, the weight of their heads cauſing them to fall outwards, and faſten upon it; then the weight, 4, puſhes up the bolt, Y, into the drum, which locks it to the great wheel, and ſo the ram is drawn up as before.

As the follower comes down, it cauſes the drum, C, to turn backward, and unwinds the rope from it, while the horſes, the great wheel, pinion X, and fly, go on with an uninterrupted motion; and as the drum is turning backward, the counterpoiſe is drawn up by its rope, T, winding upon the ſpiral fuſee D.

There are ſeveral holes in the under ſide of the drum, and the bolt, Y, always takes the firſt one that it finds, when the drum ſtops by the falling of the follower upon the ram, till which ſtoppage the bolt has not time to ſlip into any of the holes. But the ſame effect is more certainly produced by a crooked lever, *t*, *fig.* 9, fixed on the framing R, over the end of the vertical ſhaft; one end of this has a roller, which is preſſed upon by the great rope, H, the other end holds down the catch, 5, of the forcing-bar, but as ſoon as the great rope ſlackens, it retires, and gives liberty to the ſmall lever, 3, to puſh up the bolt. As long as the great rope has a tenſion upon it, to ſupport the weight of the ram or follower, the crooked lever is kept in cloſe contact with the forcing-bar, and when that is depreſſed, (to diſcharge the bolt Y,) by locking over its catch, 5, the crooked lever keeps it down, till the follower touches the ram; the great rope then ſlackens, and the ſpring, *v* H, diſcharges the crooked lever from the catch of the forcing bar, and gives liberty to the ſmall lever, 4, to puſh up the great bolt, and to lock the drum to the great wheel, and the ram is drawn up again as before.

The peculiar advantages of this engine are, that the weight of the ram, or hammer, may be raiſed with the force of horſes inſtead of men; that when it is raiſed to a proper height, it readily diſengages itſelf, and falls with the utmoſt freedom; that the forceps or tongs are lowered down ſpeedily, and inſtantly of themſelves again lay hold of the ram, and lift it up; on which account this machine will drive the greateſt number of piles in the leaſt time, and with the feweſt labourers.

The piles at Weſtminſter bridge, when driven by the above machine till they were quite firm, were cut off, under water, by a machine, to be level with the ſurface of the ground to found the piers upon. This machine conſiſted of a framing which was adapted to fit upon the upper part of the pile, and could be fixed faſt thereto. The lower part of this frame formed guides for the ſaw, which reciprocated horizontally at a certain depth beneath the top of the pile, and had weights to cauſe it to advance up to the cut. The ſaw was put in motion by ropes from each end, which were conducted, over proper pullies, to two men ſtanding on a float or raft at the ſurface. After fixing the machine, before the ſawing was begun, the whole machine was ſuſpended by a tackle, which therefore took up the top part of the pile with the machine as ſoon as it was cut off. This was the invention of Mr. Etheridge, carpenter to the works at Weſtminſter bridge; it was very effective, as the time employed in cutting off a fir pile of 14 or 16 inches ſquare, in ten feet depth of water, was ſeldom more, and often leſs, than a minute and a half. A machine, more convenient than this in its application, and not leſs effective, has been ſince invented by Mr. Foulds, to whom the Society of Arts preſented a gold medal for the invention; ſee *figs.* 5 and 7. A A B is the external frame, conſiſting of four parallel rails A, framed into two others, B, at right angles, with proper croſs pieces to unite them, and inclined to ſtrengthen the whole; within this frame a ſecond, or internal frame, D E, is ſituated; like the other, it has four parallel pieces, D and E, connected together into one frame by croſs pieces; at the top it has two pieces *a*, *a*, which reſt upon the beam B, and ſuſpend its weight, and on theſe it is capable of ſliding backwards and forwards between B B, always preſerving its parallelism, becauſe it is moved by the racks, *d*, *d*, affixed to it, one at top, and the other at the bottom; the pinions for both are fixed on a vertical axis *e*, ſupported in the external frame; therefore, by turning the handle *r*, the internal frame with the ſaw is advanced to the pile, as at K, *fig.* 6. The ſaw itſelf is ſuſtained in a frame L, *fig.* 7, which fits, in the manner of a ſaſh frame, between the two beams, D, of the internal frame, and has racks, *f*, *f*, (dotted) behind it, which work in pinions on an axis *g*, extended acroſs the frame, and by the handle, *y*, of this it is capable of being drawn up and let down, or detained at any height by a ratchet-wheel and click *x*; the ſaw, *m*, is fixed upon a ſpindle N, ſupported in bearings on the frame L, and turned by the handle, R, at the top; the ſaw is connected with the ſpindle by a piece of iron *p*, having a mortiſe through it for the reception of the ſpindle, to which it is faſtened by a nut beneath: by this means the ſaw's edge may be advanced as the work goes on.

In uſing this machine, the beams, B, are fixed acroſs a barge, which is ballaſted till they are horizontal, and the ſpindle of the ſaw is therefore vertical in this ſtate; it is moored with her ſide againſt the pile, K, to be cut off, as

shewn by the dotted line V, *fig.* 6; then by the rack and pinion *f g*, the saw is adjusted in height to the level where the pile is to be cut; by the handle *r* it is advanced to the pile K, whilst by the other handle, R, the saw is kept in continual motion backwards and forwards, till the pile is cut through, and the piece is taken into the barge, which proceeds to cut off the next by the same means. By this machine temporary piles, which are used in coffer-dams, may be cut off level with the bottom, when the work is finished, which is a very superior method to drawing them up out of the ground, as is the usual practice, because this must necessarily make a deep ditch or trench all round the pier or foundation, and tend to loosen the ground. To draw piles out of the ground when they have been driven fast, requires a very great force. There are different methods of exerting this force: one for drawing them in water, is by having a very strong barge, with a windlass at one end to receive a strong chain, which is passed several times round the head of the pile, and made fast to the barge; two long beams are laid upon the barge to form a railway for a small waggon to run upon from one end of the barge to the other, and it is loaded with stones of several tons weight; when this is wheeled to one end of the barge, it will of course depress it in the water, elevating the other; then, in this state, the lowest end of the barge is chained to the pile by putting a very large bolt through it, and passing a chain round the pile under this bolt a great many times; the carriage is then wheeled to the other end of the barge by a windlass and rope; this tends to raise the end to which the pile is fixed; and when the carriage is so far advanced that it exerts a sufficient power, it will draw up the pile if the chain is properly fixed: the carriage is now returned to draw another pile.

A plan has been adopted at the new bridge now building across the Thames at the Strand, for drawing the useless piles by one of Mr. Bramah's hydrostatic cylinders. This is represented in *fig.* 10, where A is supposed to be the top of a range of piles forming the coffer-dam, and B the pile which is to be drawn. A chain, *a*, is made fast to the pile, and carried many times round a large beam C D, the end, D, of which rests upon a fulcrum, or support E, consisting of a block, supported on the head of a neighbouring pile, &c. F is a block of wood, screwed together in two places, and inclosing between them a cast iron cylinder *b*, into which is fitted the piston, or cylinder *d*, the joining being made tight by a collar of leather; *e* is a small copper pipe, communicating with the cylinder, and also with a small forcing pump, the piston, *f*, of which, is actuated by the lever *g h*; the pump is fixed upon the top of a small cistern, *k*, to contain water. Now by working the lever of the pump, water is injected into the cylinder *b*, and protrudes the piston, *d*, from it with a force proportioned to the force exerted upon the lever, in the same degree as the areas of the pump to that of the cylinder multiplied by the proportions of the lever *h*. (See this principle more fully illustrated under MACHINERY, and PRESS, *Hydrostatic.*) By this means the power of one or two men is increased to such a degree, as to draw up the largest pile; the copper pipe, *e*, is made to unscrew at several joints, which are provided with leather, to make them tight; by this means the pump is separated when the machine is to be removed. As it has no connection with the beam or lever D, the cylinder is frequently employed in the manner of a hand jack, for any purposes where enormous weights are to be lifted for a small space; the collars of leather are the same as are used in the presses. The same figure also shews a very complete way of catching fast hold of the pile, instead of putting a bolt through the pile head to stop the chain under: it is simply a strong iron ring, *l*, large enough to drop over the pile loosely, and having a strong shank or eye, *m*, projecting from it to run the chain through; and when this is drawn, the ring jambs so forcibly upon the wood of the pile, as to draw it out of the ground rather than slip off, for it holds faster in proportion to the force.

The theory of Mr. Valoue's engine depends on the following principles, *viz.* 1. If the resistance of the ground, and the masses of the piles be equal, the depths to which they will be driven with a single blow will be as the product of the weight of the ram into the height through which it falls.

2. If the masses of the ram, and heights through which it falls are both equal, the depths to which the piles will be driven, will be in the inverse ratios of the masses of the piles into the superficies of that part of them which is already immersed in the earth.

3. If all these things be unequal, the depths will be in a ratio compounded of the direct ratio of the heights through which the ram falls into its mass, and the inverse ratio of the mass of the pile into its immersed superficies.

4. If the weights of the ram be equal, and also the weights of the piles, the depths to which they will be driven will be as the heights through which the ram falls directly, and the immersed superficies of the piles. Or, because the immersed superficies of the piles are as the depths through which they are already driven into the earth, these depths are simply as the square roots of the heights through which the ram falls.

These principles are founded on the general supposition that the space through which the weight falls is estimated by the product of its mass into the square of its velocity, or into the height through which it falls.

Hence it is inferred, that the distance through which a pile will be driven by each succeeding blow will be less and less, as the superficies of that part of the pile which is immersed in the ground increases; and, consequently, that there is a certain depth, beyond which a pile of a given mass and scantling cannot be driven; the mass of the ram and the height through which it falls at first being assigned. It appears also, that the loading the pile with weights, and thereby increasing its mass, will be so far from accelerating its descent, that it will absolutely retard it. See some curious observations on the structure and operation of this engine by Mr. Bugge, professor of astronomy and mathematics in the academy of Copenhagen, &c. in the Phil. Trans. for 1779, vol. lxix. part i. art. 12.

PILE is also used, among *Architects*, for a mass or body of building.

Pin

PIN, in *Commerce*, a little neceſſary implement, chiefly uſed by the women in adjuſting their dreſs.

The form and application of this little article need no deſcription; but its conſumption, and the number of hands it employs, are too conſiderable to be paſſed by unnoticed.

Pins are now moſtly made of braſs-wire: formerly they likewiſe made them of iron-wire, which, being blanched, like the others, paſſed for braſs; but the ill effect of thoſe pins has almoſt altogether diſcarded their uſe. The French, however, could not be driven off from them without ſeveral arrets of parliament. By a ſentence of the lieutenant de police, July 1695, the ſeizure of ſome millions of thoſe pins was confirmed, and the pins condemned to be burnt by the common executioner.

The pins moſt eſteemed in commerce are thoſe of England. The method of manufacturing this uſeful article, that has been long practiſed, is as follows. The braſs wire, of which theſe implements are now almoſt wholly made, is generally too thick for being cut into pins. It is, therefore, reduced in ſize, by cauſing it to paſs through a ſmall hole in a piece of iron. When it has been reduced to a proper ſize, it is ſtraightened, and ſubſequently cut into proper lengths; and again afterwards cut into ſmaller ones, each length being ſufficient for making ſeveral pins. Each end of theſe pieces is pointed, ſo as to be ſharp enough for penetrating, without difficulty, through linen, paper, &c. by either men or boys, ſeated before two ſmall grinding-ſtones, or ſteel-mills, that are turned by a wheel, either by means of machinery or of the hand. Theſe ſtones, or ſteel-mills, are uſed for making the rough point, and for ſmoothing them; and, therefore, they are careful to turn the wire, ſo as to render the points uniform and regular. The pin is afterwards cut off to the length that is wanted, from each end; and the proceſs is repeated; till the whole of the length is pointed. The manufacture of the head is performed by the following operations. A piece of wire, ſuitable for heads, is ſpun on another; and thus the inſide wire occaſioning the

upper wire to be hollow, when drawn off, is then in the ſtate required for being cut into heads: this is done by ſhears, every two rounds of the wire making a ſingle head. The next proceſs is that of heading the lengths, which is done by the operators or work-people taking up a ſingle length, and thruſting it among the heads, and then immediately placing it under a heavy weight or hammer; when receiving the neceſſary blow, it is made ſecure; and thus the pin is completed in the firſt ſtate. After this it is to be blanched or whitened, which is accompliſhed by putting the pin in a copper, containing tin and the lees of wine. When this is completed, the pin is in a ſtate for ſale, at the option of the buyer, either in a looſe ſtate, or ſtuck in paper for the convenience of the conſumer.

Some ſucceſsful attempts have been lately made by the well-known manufacturers, Meſſrs. Durnford, Francis, and Co., of Gracechurch-ſtreet, London, for putting on the heads of this very uſeful little article, with greater expedition and uniformity than had been previouſly done by others. We are not at liberty to diſcloſe the proceſs, which is ingenious, practicable, and expeditious; but to every effort for the improvement of this, and of every other article of Britiſh manufacture, we cannot but wiſh ſucceſs.

The perfection of pins conſiſts of the ſtiffneſs of the wire, and its blanching; in the heads being well turned, and the points filed.

The London pointing and blanching are in moſt repute; becauſe our pin-makers in pointing uſe two ſteel-mills, (which are alſo occaſionally uſed in the country,) the firſt of which forms the point, and the latter takes off all irregularities, and renders it ſmooth, and as it were poliſhed; and, in blanching, uſe block tin, granulated: whereas in other parts they uſe a mixture of tin, lead, and quickſilver; which not only blanches worſe than the former, but is alſo dangerous, on account of the ill quality of that mixture, which renders a puncture with a pin thus blanched very difficult to be cured.

The conſumption of pins, and the number of artificers employed in the manufacture of them, are incredible. In Paris alone, there were anciently above one thouſand people employed in it; and after the decline of this manufacture in the city, there have been annually ſold above fifty thouſand crowns worth of the pin-wire to the pin-makers of the neighbouring places, all brought thither from Stockholm. In the little town of Rugle, in Normandy, there were computed at leaſt five hundred workmen employed in the pin manufacture; the whole town being peopled with them. Several thouſand perſons are employed in this manufacture, in various parts of our own country. Eſtabliſhments of this kind are to be found in the Metropolis, Warwickſhire, Glouceſterſhire, Eſſex, &c.

Notwithſtanding that there is ſcarcely any commodity cheaper than pins, there is not any one that paſſes through more hands before they come to be ſold. They reckon twenty workmen ſucceſſively employed in each pin, between the drawing of the braſs-wire, and the ſticking of the pin in the paper.

Pins are diſtinguiſhed by numeros; the ſmaller called from N° 3, 4, 5; thence to the 14th; whence they are only accounted by two to two, *viz.* N° 16, 18, and 20, which is the largeſt ſize.

Beſides the white pins, there are alſo black ones made for mourning, from N° 4, to N° 10. Theſe are uſually of iron-wire.

Laſtly, there are pins with double heads, of ſeveral numeros; uſed by the ladies to fix the buckles of their hair for the night, without danger of being diſturbed by their pricking, &c.

The manufacture of both braſs and iron pins is thought by ſome perſons to be in a degree injurious to the pointer; as it is imagined he imbibes, in the courſe of ſome years, a quantity of the duſt which flies off the wire, and which, in that caſe, muſt be pernicious. He is alſo liable, from the conſtant preſſure of his thumb on the ſtones, to a weakneſs in it, which not unfrequently renders him incapable of continuing the operation of pointing.

We are ſorry to learn that the pin manufacture is leſs proſperous than it was ſome years ago. This decline is partly owing to the diminiſhed conſumption of this article by our fair country-women, and of courſe partly to the exceſs of the quantity made above the regular demand; which has occaſioned to the maſter-manufacturer not only an inconvenience, but a diſproportionate return of profit for the capital which it employs. Upon the whole, it is thought, that this uſeful claſs of perſons is decreaſing in number; and that there are no very encouraging expectations of the manufacture's ſoon reviving and flouriſhing.

The firſt mention of pins that occurs in the Engliſh ſtatute-book, is found in the ſtatute of Richard III. in 1483, prohibiting foreign manufactures; and it appears from the manner in which pins are deſcribed in a ſtatute of the 34th and 35th of Henry VIII. cap. 6, A.D. 1543, and the labour and time which the manufacture of them would require, that they were a new invention in this country, and probably but lately brought from France. However, in about three years time, they fell into the preſent ingenious and expeditious manner of making them.

One of the articles of the ſtatutes of the ancient pin-makers of Paris was, that no maſter ſhould open more than one ſhop for the ſale of his wares, except on new-year's day, and the eve thereof: this we mention in an age of luxury and profuſion, to recollect the agreeable ſimplicity of our forefathers, who contented themſelves with giving pins for new-year's gifts.

Hence the cuſtom of ſtill giving the name *pins*, or *pin-money*, to certain preſents, which accompany the moſt conſiderable bargains; in which it is uſual to give ſomething towards the pins of the wife, or children, of the perſon with whom the bargain is ſtruck.

Pipe

PIPE, a clofe channel for the conveyance of water, or other fluids, is of fuch extenfive ufe in building, &c. as to render the confideration of its materials, and beft means of forming its joints, a matter of importance to architects and engineers, that they may give ftability and durability to their work, at the leaft expence. Water-pipes are made of wood, iron, lead, copper, ftone, or pottery; and each of thefe materials, in different fituations, has its preference.

Wooden-pipes may be procured in all countries at a fmall expence, are eafily made, and joined together; but the great objection is their want of ftrength to refift a ftrong preffure without breaking, and their liability to decay. For water-works they are ufually made of elm, or alder; oak, though far preferable, being too expenfive. They are beft made from fmall trees of the proper fize; and then the bark, being left on, is thought to preferve them. The paffage is bored out by a long auger, turned round by one or two men; whilft the tree is fupported in a convenient pofition on treffels, and bound faft down upon them by ropes, to which weights are attached.

In towns where water-works are eftablifhed, the demand for pipes is fuch as to render this method too expenfive; and machines are ufed to bore them, turned by horfes, water, or fteam-engines. The pipe-boring machine is extremely fimple. A pit is firft dug, fimilar to a faw-pit; on each fide of this a long timber is fixed, and the two being united, at various points, by crofs framing, forms the bed, on which the fledge flides backwards and forwards as great a diftance as the length of the tree which is to be bored. The fledge is a frame of wood, upon which the tree is laid when it is to be bored, and is firmly held upon it by chains paffed over it, and drawn exceedingly tight with windlaffes fixed in the fledge. Wedges of wood are ufed to fupport it from rolling fideways, and to raife it up to fuch a height, that the borer will pafs through the centre of the tree. The borer is fixed at the extremity of a fpindle, fupported by bearings, on blocks raifed from the crofs framing of the bed at one end, and which are adjufted, that the line of the borer will be exactly parallel to the bed and fledge: the fpindle is put in motion by wheel-work from the mill, fo as to revolve 30 or 40 times *per* minute. The fledge with the tree is advanced towards the borer by ropes, which are conducted over proper pullies, from each end of the fledge, to the barrel of a wheel, with handles on its circumference, fimilar to the fteering-wheel of a fhip: therefore, a man, by

turning the wheel one way, advances the ſlider, with the tree towards the borer, which penetrates into the end of it; but on turning the wheel in an oppoſite direction, it is withdrawn, to clear the chips of wood. This is repeated till the pipe is bored through. The borer can be detached from the ſpindle, to employ another of greater or leſſer diameter, when the pipes require it. The elm pipes employed in the ſtreets of London for the diſtribution of water, are made by this means, except ſuch trees as are crooked: theſe are bored by hand augers, becauſe they muſt be pierced from both ends to meet in the middle, which the machine will not readily do.

The lengths of pipe are joined together, by enlarging the bore at one end in a conical form, with a ſort of auger, and cutting the oppoſite end taper, to drive into the conical end of the adjacent pipe, which is hooped to prevent it from ſplitting. This method is a very bad one, very ſoon decaying, even when the taper end is fitted perfectly, becauſe the thickneſs of the wood at the taper part is ſo very ſmall. In the uſual mode of fitting them, by merely ſhaping the conical part with the axe and drawing-knife, whilſt the workmen are perhaps over ſhoes in mud, and expoſed to bad weather, it is ſcarcely reaſonable to expect them to be very attentive; but the joint is fitted in haſte, and diſpatched as quick as poſſible: the conſequence is, that the conical part being correctly bored, whilſt the taper is made to an irregular and more obtuſe cone, the joint fits only at a very narrow point; but if well driven, will make a tight fitting at firſt, and, when buried, eſcapes detection; but in the courſe of a very few years, the vacant ſpace round the end of the taper accumulates mud, which haſtens the decay of the wood, and the joint fails. From theſe circumſtances, the pavement of the ſtreets is conſtantly broken up, the way impeded, and the ſupply of water ſuſpended. The Society of Arts have, under theſe conſiderations, offered a handſome premium, for ſeveral years paſt, to procure a complete remedy for theſe defects. Mr. Hornblower propoſed a tool, or bit, to form the taper end of the pipe, with the ſame certainty as the cone which is bored. It conſiſted of a wooden plug, fitted to the bore of the pipe, and having through its centre a hole, for the reception of a round iron rod or axis, which has a croſs handle at the end, like an auger, to turn it round by. Near the handle, its ſize is ſufficiently enlarged to have a mortiſe, for the admiſſion of an iron arm, which can be fixed in it by a wedge. This arm turns down, and carries a ſteel knife, the edge of which, by the bending, ſtands inclined to the round rod, in the angle the conical taper is to have: therefore, by turning the handle round, the edge of the knife deſcribes the ſurface of the cone, and cuts away the wood of the pipe to that form; the round rod, being of conſiderable length, can ſlide freely in the plug at the end of the pipe, and allow the cutter to be thruſt up, to cut by degrees, till it reduces the taper. The uſe of this tool would enſure the perfect fitting of the joints; but ſtill the plan is defective, as before mentioned, from the ſmall quantity of wood round the joint. Another kind of joints have, therefore, been propoſed: in theſe the adjacent ends of the pipes to be joined are both bored out, by a taper bit, to hollow cones; and the two are united by a ſhort iron tube, which is made in form of two truncated cones joined at their baſes, and of dimenſions correſpondent with the conical baſes in the ends of the pipes. This plan is very far preferable to the former, both in ſtrength and durability; and as the tubes are made of caſt-iron, it is not an expenſive one.

Meſſrs. Eckhardt and Lyon obtained a patent in 1806, for a method of making wooden pipes by ſeparate ſtaves, reſembling a barrel, but of leſs curvature, and greater proportional length, ſo as to approach near to a cylindrical form, particularly withinſide. They are to be bound by iron hoops, made faſt either by driving them on from the ends, or by ſcrewing the hoops together: the lengths are to be joined together, by forming one end of each taper, and enlarging the correſponding ends of others to receive them: the ſtaves are to be fitted by tongues, rabbiting, or dovetailing. We have not heard of this method having been practiſed to any extent: it would, we think, be very expenſive, and have all the defects of wood pipes; being liable to ſpeedy decay, when buried in the ground. And it generally happens, that in their rotten or decayed parts they generate inſects and animalculi in vaſt numbers; which may always be diſcovered in water that has paſſed through wood pipes or pumps, which have been long in uſe. Dr. Buchan obſerves, that ſuch water becomes putrid by the corruption of the animal and vegetable bodies with which it abounds.

Iron-pipes are caſt at the iron-founderies of any dimenſions; and for durability and ſtrength combined, are greatly ſuperior to any other material: they may be procured in lengths of ten feet, and united by nuts and ſcrews paſſed through flaunches, caſt on the ends of them. Moſt of the great Companies for ſupplying London with water have, within theſe few years paſt, adopted caſt-iron pipes for their mains, and are daily increaſing them, under the conviction that their permanency will compenſate for the firſt expence. They are uſually caſt in lengths of ten feet, one end with an enlarged ſocket of ſufficient ſize to receive the end of the next pipe. As theſe joints cannot be driven cloſe, to fit like wooden joints, they require ſome cement. To apply this, they firſt caulk it, by driving a ſmall quantity of hemp down to the bottom of the joint with a blunt chiſſel, and then fill the remainder of the ſocket with iron cement; which is a compoſition of borings or turnings of caſt-iron, mixed up with ſulphur and ſal ammoniac. This is moiſtened with water, and rammed into the cavity; and the rapid oxydation of the iron borings unites them into one maſs, and at the ſame time expands the bulk of the cement, ſo as to fill up all the ſpace very cloſely. The hemp, firſt driven into the joint, is only to prevent the cement getting into the pipe, and to keep the water from it till it is ſet firmly; after which, the joint is as ſolid as any other part of the pipe. Another method, much uſed for large pipes, is to have two ears projecting from each pipe at the joint, through which ſcrew-bolts are paſſed, to draw them cloſe together. The joints are ſometimes filled with lead run in, whilſt melted; and others have uſed the Roman cement to bed the joints in.

Within theſe few years immenſe quantities of iron pipes have been laid in all parts of London, for the conveyance of water, which no ſooner became generally known, than great prejudices were excited againſt them, under the idea that they would give the water a metallic taſte, which would be injurious to the health of the inhabitants. This is clearly an error, as any one may aſcertain, by examining an old ciſtern, or veſſel of caſt iron, which has only had freſh Thames water in it; and they will find it coated with a ſort of japan, or ſmooth ſurface of a black colour, which is a very thin oxyd, and does not penetrate any depth: though if the water is of ſuch a quality as to produce red ruſt, the iron is corroded very faſt, but is ſtill a very harmleſs mixture. Water having any lime in it, depoſits a thin coat or incruſtation withinſide iron pipes, and thus completely defends them from corroſion; nor is there any danger, as ſome have ſuppoſed, of this incruſtation increaſing

so as to stop the pipes in course of time, because the water only deposits the stony matter from the attraction of the iron, which being once covered with a slight thickness, the water has no longer access to the iron. We have heard of an expedient of putting lime into the water, when it was found that the water was so corrosive as to become tinged by running through iron pipes newly laid down. A rapid current of this lime-water being caused through the whole length for a few days, the pipes became coated with the calcareous matter. At first, after this, the fresh water tasted of lime, but it became pure in a short time, because, in the first instance, more lime was deposited than could be combined with the oxydated surface of the iron, and this excess would of course be carried away again by the fresh water, but no more.

Stone Pipes.—The prejudice the public at first entertained against iron pipes, induced many projectors to find out other substances, which would have the strength and durability of metal. Sir George Wright proposed stone, and invented a machine for cutting out cones from the hollow of the pipe. He first employs a boring or drilling machine, to pierce a small hole through the centre of the block of stone, in the axis of the intended pipe. Another machine is then used, consisting of a saw applied in a frame, which revolves on a round iron rod, passed through the central hole previously drilled: the frame gives the means of fixing the saw at any required distance from the rod, and attaching it firmly thereto at each end: its edge will of course, when turned round, describe the surface of a cylinder, of the diameter of the intended pipe. The saw and central rod are rather longer than the block of stone, which permits them to be moved backwards and forwards endways, to give the motion of sawing with sand and water in the usual manner. In their operation, the block of stone is placed with the rod horizontal; the saw is entered at another hole, previously drilled through the stone, and as the saw cuts, the central rod guides it round on a centre, till it separates the core all round, and this being taken out, leaves a pipe or tube. Sir George obtained a patent for this invention in 1805, and it was practised for some time, and many large stone pipes were laid; but great difficulties arose in making good joints: they were attempted by Roman cement, which adhered so well, as to make them perfect, if the pipes were well bedded; but the continual tremor of heavy carriages passing over them soon disturbed many joints, and broke the bond of the cement. Mr. Samuel Hill took out a patent in 1810, for uniting these pipes together at every joint by a collar of stone, into which the extremities of two pipes are made to fit, so that about two inches of each shall enter it, and reach to its centre, where they are to meet. A sufficient quantity of cement is to be spread on the ends of each pipe, and in the internal part of the collar, before they are inserted into it, to prevent water from passing through the joints. Although this obviates one difficulty, still the expence of stone pipes is prodigious; at least in London, where the price of materials alone, without any cost of workmanship, would be too great. In situations where that material is plentiful, they may be used, and the labour of making them will be reduced very low by a machine invented by Mr. Murdoch, and for which he had a patent in 1810: it is very superior to the above, which is only applicable to large pipes; besides, the trouble of previously drilling two small holes the whole length of the pipe is wholly saved.

When it is intended to form a pipe or hollow cylinder of stone by Mr. Murdoch's machine, instead of reducing the whole inside to powder, it is sawed in the form of a core, or solid cylinder, the diameter of which is about half an inch less than the diameter of the inside bore of the pipe. In like manner, when a solid column or cylinder is to be formed, the outside and superfluous parts of the stone are taken away by a similar process, and the core forms the column or cylinder required. When the stones are large enough to leave the outside parts of a proper thickness, they may be used as pipes; or the cores cut out of large pipes may be used as columns, or formed into smaller pipes, so that in some cases several may be cut out one within another. The method by which these are formed is the following:

The block of stone, out of which the pipe is to be formed, is placed in a vertical position, and a plug of wood or metal is fixed in the top of the block, at the centre of the intended pipe; this plug has a hole in its centre, for receiving the lower pivot of a vertical spindle or axis, which is made longer than the pipe is required to be. The rod is of an uniform thickness, and made either square, triangular, or any other shape that will admit of sockets sliding freely up and down, without turning round upon it. On the upper part of this spindle a socket is fitted, having on the middle part of its outside a pulley or a small-toothed wheel, by which the axis or spindle may be turned round. The upper and lower extremities of this socket are cylindrical, and serve as gudgeons, upon which it turns in a frame, and steadies the axis. Near the lower end of the vertical axis a wheel with arms is fixed, having the circumference like a hoop two or three inches broad; and its diameter a little less than the diameter of the pipe to be bored: it fits to the inside of a tube of metal, which is attached to the spindle, and kept concentric with it, by being fitted over the wheel. The upper part of the spindle is perforated to a little below where the above-mentioned socket is fixed, and then the perforation comes out obliquely. The tube is of a diameter nearly equal to that of the pipe to be formed, and exceeding it in length about two feet: this pipe is made as truly cylindrical as possible, and is attached to the axis by another wheel across, similar to that at the bottom, which is fixed in the tube at the upper end, and fits upon the square spindle, to slide freely up and down, without turning round upon it; this tube being, as before-mentioned, guided by fitting on the wheel fixed at the lower part of the spindle. On the lower edge of the tube a rim of proper metal is fixed, which is so much thicker than the tube, that the groove it makes in the stone may admit the tube to move freely. This hoop being intended to grind or saw the stone, has its lower edge either left smooth, or formed like the saws used by stone-cutters. The wheel or cross, which is fixed on the vertical tube, near its upper end, has a small cord or chain fastened to one of its arms, and passes upwards through the perforation in the upper part of the axis, and then over a pulley fixed at a convenient distance above it: it serves to raise the tube on its axis when required. On the upper part of the tube weights are fixed, for the purpose of making it act more forcibly upon the stone, if necessary. When the apparatus is to be put in motion by the force of man, the above-mentioned pulley, fixed in the socket near the upper part of the axis, is generally made about double the diameter of the pipe to be bored, and a rope passes round it, each end of which is conducted over a vertical pulley, fixed at a convenient distance, on each side of the machine; by which means the ends of the rope turn downwards, and having handles fixed to them, are pulled alternately by a man at each end, so as to cause the tube to make a reciprocating rotative motion about its axis or spindle; or the apparatus may be put in motion by any other power, only if the pulley and cord be retained, a spring or a sufficient weight acts

at one end, while the power operates on the other by means of a crank, or other ſimilar contrivance. Or, inſtead of the pulley, a toothed wheel or pinion is ſubſtituted, and acted upon by a reciprocating toothed wheel, belonging to the mill, engine, &c. connected with the moving power, or by a reciprocating rack or ſector, put in motion by the ſame power or machinery. A ciſtern is placed at ſome convenient height above the tube, by means of which, a mixture of water and ſand is conveyed into the tube, and forces its way under the ſaw, when in motion, and cauſes it to abrade or grind away the ſtone, and form in it a circular groove, concentric with the axis. As the groove becomes deeper, the water accumulates in the tube, and forces the ſand with it under the ſaw and both are diſcharged over the outer edge of the tube, in the form of mud or ſludge, and the motion of the tube may be thus continued as long as the moving power is maintained. When any circumſtance cauſes this to ſtop, the tube muſt be drawn up by means of the cord and pulley for that purpoſe, or the ſand will ſet faſt round the tube, and will not be eaſily freed again.

Copper-pipes are too expenſive to be employed except in particular ſituations. They are made of copper plate turned up and ſoldered, and are much uſed in diſtillers' work, becauſe they can be tinned withinſide, and then communicate no taint to what paſſes through them.

Lead-pipes are univerſally employed for all ſmall water pipes, chiefly from the facility of bending them in any direction and ſoldering their joints. Although ſome kinds of water corrode the metal by degrees, this will not produce ſo much harm as iron under the ſame circumſtances, but would be a moſt dangerous poiſon if it was uſed in ſufficient quantities to have any effect at all.

The greateſt proportion of the leaden pipes uſed in water-works, was, till of late years, made of ſheet lead wrapped round an iron or wooden core, and the joint ſoldered up. The expence and trouble of this method was conſiderable, and the pipes thus made extremely liable to burſt at the joint, particularly if bent with a ſudden angle. Theſe defects ſuggeſted the idea of caſting the lead in the form of pipes, by which means the trouble of previouſly caſting and laminating the lead into ſheets would be ſpared, and alſo the uncertainty of the ſoldered joints. Such pipes are caſt in an iron mould, made in two halves, forming, when put together, a hollow cylinder, of the ſize of the intended pipe. A core, or iron rod, the ſize of the bore of the pipe, is adapted to this hollow mould when the halves are put together, and ſecured by ſcrews or wedges, ſo that it exactly occupies the centre of the hollow mould, leaving therefore an equal ſpace all round between them. A ſpout, or entry for the admiſſion of the melted lead, is made by a correſponding notch cut in each half of the mould, and at another place is a ſimilar vent for the eſcape of the air. This mould is fixed down upon a long bench; and a rack, moved by toothed wheels and pinions, is fitted up at one end of it, in a line with the centre of the mould. A hook at the end of the rack, being put into an eye at the end of the core of the mould, affords the means of drawing out the core, when the pipe is caſt round it by pouring the melted lead into the mould, with the core in it: when the lead is cold, the core is drawn out very nearly to the end of the pipe, by the rack and wheel-work before mentioned. The halves of the mould are then ſeparated, and the pipe moved along in the mould, ſo that only an inch or two of its end remains in the mould, the halves of which are again faſtened together with the core between them, and its end entered an inch or two into the firſt piece of pipe. The mould is now filled with melted lead, the heat of which fuſes and unites it with the end of the firſt piece, ſo as to double its length. The core is again drawn out a ſecond time, and another length caſt to the former. This method produces pipes of any length in one piece, but they are liable to have air-bubbles in them, which produce holes when the metal is thin, and the joinings of the different lengths are not always perfectly ſound.

The method which is now very generally adopted, is to caſt the lead in an iron mould, upon a cylindrical iron rod of the ſize for the bore of the intended pipe, the lead being three or four times the thickneſs of the intended pipe, and in ſhort lengths, which are then drawn through holes in pieces of ſteel, in the manner of wire drawing, till the pipe is reduced to the intended thickneſs, and drawn out to the proper length. Another method is to reduce the pipe by repeatedly paſſing it through the two rollers of a flatting mill, in each of which a number of ſemi-circular notches are formed all round, ſo that the two rollers, when put together, have a number of circular cavities between them, which gradually diminiſh in diameter from one end of the rollers to the other. Drawings of ſuch rollers will be found in our plates of *Iron Manufacture*. The pipe is firſt rolled between the largeſt of theſe cavities, then in a ſmaller, and ſo on to the laſt, which extends the pipe to its proper length, and diminiſhes its ſubſtance to the proper thickneſs, at the ſame time by condenſing the metal hardens it, and makes a very ſtrong tube with very little metal. Mr. John Wilkinſon of Broſely, the celebrated iron manufacturer, took out a patent, in 1790, for the laſt mentioned method, which he practiſed on a very extenſive ſcale: he was not, however, the original inventor, the ſame thing having been propoſed, in 1728, by M. Fayolle; ſee "Machines Approuvés par l'Academie Royale," vol. v. p. 50. Since the expiration of this patent many manufactories of this article have been eſtabliſhed, ſome employing rollers, and others the draw-bench, for extending the pipes.

We have given a repreſentation of one of the latter machines in *Plate* XL. *Mechanics*. *Figs.* 1 and 2 are ſections of the mould for caſting the pipes; A A is the bench, ſupported on legs like a ſtool in an inclined poſition; B, B, are the two halves of the mould, fitted into each other with double rebates, as ſhewn in the ſection *fig.* 1, that they may come together correctly, and are held ſo by the ſcrews D, D, fitted through pieces of iron E, E, faſtened to the bench; the halves of the moulds have at each end a flat ſide beneath, which reſts upon the iron plate connecting the two pieces E, E; F is the core, held in its poſition by collars at each end of the mould embracing it; G is the rack, and H I K the wheel-work for drawing out the core; *d* is the entry for the metal, raiſed up to the ſame level as the higheſt point the metal is intended to run into. The intention of the inclined poſition for the mould is, that the metal may run in at the loweſt point of the mould, and expel the air as it riſes, at a vent in the higheſt point of the mould, which is *e*. By this means the danger of air-bubbles in the pipe is avoided. The interior ſurface of the mould is bored out truly cylindrical, and the core being turned in the lathe, they are certain when put together to leave an equal ſpace all round, a circumſtance which is eſſential to form a good pipe, as the ſucceeding proceſs of drawing will tend to make an error of this kind worſe. The core, F, is ſeen in *fig.* 2 to have a neck or ſmaller part at the end *d*: the treblet or core *a g*, *fig.* 3, upon which the pipe is to be drawn, is of the ſame ſize, and has a ſimilar neck, ſo that the pipe, when put upon it, fits it in every part, as is ſhewn in *fig.* 3, and the ſhoulder of the neck prevents the treblet being drawn through the pipe in the direction from *g* to *a*, as it was put in by the oppoſite direction. Beyond the neck the treblet has a notch cut in each ſide at *g*, leaving

a neck; and by this it is ſeized in a ſort of claw belonging to the draw-bench, which is exhibited in *figs.* 4 and 5, the former being a plan, and the latter a ſection. In theſe L, M, are two ſtrong timbers, bolted to uprights N, O, at one end of each, and to a croſs beam, W, at the other end; the uprights ſupport bearings for the gudgeons of a ſtrong iron ſpindle, which has the cog-wheel, *k*, fixed upon its end, and is turned round by the pinion *l*, receiving a rotative motion from a ſteam-engine or water-wheel; P is a roller, fitted on the ſpindle ſo as to ſlip round freely upon it; it has two claws affixed into it at one end, which are ſeized by the ends of an iron bar, *m*, fixed faſt upon the ſpindle. By this means, when the roller is thruſt towards *m*, it is engaged with its arms, and compelled to turn round with the ſpindle, but when drawn back from *m*, it is at liberty to ſlip round independent of it; Q is a lever affixed to a vertical axis; it is forked at the end, and embraces a collar upon the end of the roller, ſo as to draw it backwards or forwards, and by this means engage or diſengage it from the ſpindle at pleaſure; R is another lever on the ſame ſpindle, to the end whereof a long rod, S, is jointed, and this has ſeveral handles fixed to it, as ſhewn in *fig.* 5, by which it can be moved, and the machine ſtopped or put in motion by a man ſtanding at any part of the long bench L M; the roller, P, has a pair of ſpiral grooves formed on its circumference, for the reception of two chains, *n*, *n*, which wind upon it; the ends of theſe chains are hooked to a little carriage, *p*, running upon two wheels, and having in its hinder part a fork or double claw, to catch in the notches at the end of the treblet T, alſo ſhewn in *fig.* 3; X is a caſt-iron frame, ſecurely bolted down upon the croſs beam W; it has a notch in its upright ſide, which is neareſt the roller, to allow the treblet and pipe to paſs through, but at the ſame time forms a lodgment for the ſteel plate, through which the pipe is to be drawn. The workmen are provided with a great number of theſe plates, one of which is ſhewn in *fig.* 6; they are called whirtles: the ſizes of the holes through them diminiſh very gradually, from the diameter of the rough caſt pipe, to the ſize to which it is intended to be reduced. The holes through them are made rounding at each ſide, as is ſhewn in the ſection Z, *fig.* 6, to facilitate the exit and entry of the pipe. The bench is continued beyond the beam W, and has a number of rollers in it, to ſupport the pipe as it is drawn along.

The proceſs of drawing is as follows: the lead pipe being fitted upon the treblet, as in *fig.* 3, is laid upon the rollers in the bench, and the end of the treblet being put through the largeſt of the ſet of whirtles, its end is hooked into the claws in the carriage *p*, and the whirtle lodged againſt the cheeks of the frame X: the rod, S, is now pulled, which engages the roller with the ſpindle (ſuppoſed to be all the while in motion); this winds up the double chains *n*, drawing the pipe through the whirtle, by which it diminiſhes its ſize and lengthens it out: when the pipe is drawn quite through, the roller is caſt off by puſhing the rod S; the treblet is unhooked from the carriage, and puſhed back upon the rollers in the bench to its former poſition; another ſmaller whirtle is put on; the carriage is drawn back by hand (the roller turning round on its ſpindle), and the pipe is drawn through it as before. In this manner the buſineſs proceeds till the pipe is finiſhed.

Sometimes the pipe is drawn through twelve ſized whirtles in this caſe; the ſecond time, and alſo the laſt time but one, it is drawn through a whirtle ſuch as Y, *fig.* 6; it is not rounded off at the entrance, but having a ſharp edge, it cuts off ſhavings from the ſurface of the lead, making it perfectly ſmooth and true: this makes it paſs more eaſily through the ſucceeding whirtles. Lead pipes are by this proceſs drawn out to ten or twelve-feet lengths, three of which are united into one, by what is called *burning*. For this purpoſe an iron core is put through one pipe, and entered a few inches into the other: a ſmall iron mould is now put together in two halves over the ends of the two pipes which are brought in contact, the mould exactly fitting both; melted lead is poured into the mould, and it runs out again at a hole in the bottom. This is continued till it is ſuppoſed the heat of the lead has fuſed the ends of both the pipes; the hole in the bottom is then ſtopped by a ſlider for the purpoſe, and the mould remains full: when cold it is taken off, and the pipes are perfectly united. The core is now withdrawn, to facilitate which, it only fits the bore of the pipe at a few inches of the end. Theſe joints are very good if the pipe remains ſtraight, but are apt to leak if a bend is made at one of them.

In 1804, Mr. Alderſon took out a patent for lead pipes which were to be lined with tin, for the conveyance of beer, water, or other fluids which were in danger of receiving a taint from the corroſion of the lead. This he accompliſhed by caſting a lead pipe in the manner above-deſcribed, then withdrawing the core, and throwing into the pipe a ſmall quantity of powdered roſin. Another core ſmaller than the former is next inſerted into the centre of the pipe, and melted tin poured in to fill up the ſpace. The pipes are caſt in a vertical poſition, and the roſin melting by the heat floats upon the ſurface of the tin, and acts as a flux to unite it with the lead. This pipe of lead, lined with tin, is now to be drawn or rolled to length, as before-mentioned. We are informed Mr. Alderſon employs rollers to extend them inſtead of the draw-bench.

Mr. Bramah's method of making lead pipes is very ingenious; it is performed by a proceſs of pumping or forcing the metal, in its fluid ſtate, through proper moulds. A boiler or kettle is fitted up over a fire-grate, with flues for the fuſion of the metal; in the centre of this boiler a force pump is fixed up, its ſuction valve drawing in the melted lead contained in the boiler: the forcing pipe of the pump proceeds through the ſide of the boiler, and conducts the lead to the mould, which is fixed on the end of the pipe outſide of the boiler: it conſiſts of a tube, bored perfectly ſmooth and cylindrical, its interior diameter being equal to the outſide of the pipe intended to be made; the end of the mould neareſt the boiler expands into a conical mouth, larger than the mould itſelf, and acroſs this wideſt part a croſs bar is fixed, to ſupport a core or mandrel, of a diameter equal to the bore of the intended pipe, and ſituated exactly in the centre of the mould, leaving an equal ſpace all round between them: the core is ſlightly conical, being rather leſs at its extremity, which terminates at the ſame length with the external mould. There muſt be ſufficient openings left at the ſides of the croſs bar ſupporting the core, to allow the lead to paſs freely by, that it may unite again after paſſing the croſs and completely fill the mould. The mould paſſes through one of the fire flues ſurrounding the boiler, that it may be kept ſo hot as to procure the lead in its fluid ſtate, till it arrives nearly at the point of the mould, which is immerſed in a ciſtern of hot water. The operation is ſimple: the pump, being worked, forces the lead through the mould, the heat and length of which are ſo regulated, that the lead may chill a little before it quits the extremity of the mould, and iſſues forth in a ſolid ſtate into the water ciſtern, forming a pipe of any length. Mr. Bramah took out a patent for this method in 1797.

Pipes of pottery ware are uſually made of that coarſe kind of brown ſtone pot, which is very hard and durable; they can only be made in ſhort lengths, and have one end enlarged

to receive others. To close the joints tow and pitch are used, but they can never be made to bear any pressure, are liable to be broken by accident, and being very expensive, have no other recommendation than preserving the purity of the water they convey.

We have seen some water conduits from an old Roman building, which were very slight pottery tubes, buried in a mass of mortar, that by ages had acquired a hardness and closeness sufficient to resist a strong pressure.

In 1808 Mr. W. Bell obtained a patent for a new kind of pipes for conveying water, which were to be made of such substances as to give no taint to the water passing through them. He proposed tubes of porcelain pottery, and various compositions which are vitrifiable, and are not liable to corrosion or decay: these tubes are formed in such a way at the ends as to fit one within the other, and are to be made water tight by cement; they are to be enclosed in cast-iron cases, to give them strength to resist the internal pressure of water, as well as to defend them from accidental violence; or the cases may be made of wood.

Pipe, *Tobacco*, an implement used in the smoaking of tobacco, consisting of a long tube, made of a particular kind of clay baked hard: at one end a little cavity or furnace is formed, called the *bowl*, which is for the reception of the tobacco when burning, and the fumes are drawn by the mouth through the other end of the tube. The making of tobacco pipes forms a considerable trade in London and other great towns; they are made of various fashions, long, short, plain, worked, white, varnished, unvarnished, and of various colours, but the same process is followed for all of them. The clay is found in the isle of Purbeck, in Dorsetshire, and is distinguished from others by its perfect white colour, and its great adhesion to the tongue when baked, occasioned by its great affinity for water: even in the raw state it has this property in a slight degree. The clay is prepared by dissolving it in water in large pits, and the solution being well stirred, is run off into another pit, where it deposits the clay, which, when the water has become clear and run off, is taken up for use, all impurities of small stones, sand, &c. being separated from it and left in the first pit. The clay is now divided into portions, each sufficient to form one pipe, which are rolled on a table, under the hand, into long rolls, each with a bulb at the end, to form the bowl; and these are laid by a day or two, to dry sufficiently for the pressing. This is done in an iron mould, consisting of two halves, which when put together leave a cavity of the shape of a pipe; a wire is thrust up the roll of clay, to form the bore of the pipe, and in this state it is placed between the two halves of the mould, which are then put into a kind of press or vice, by the screw of which the two halves are forced together, and the figure of the pipe imprinted on the clay included between them; a lever is next brought down, which is so situated as to introduce a stopper into the bowl of the pipe whilst still in the mould, and force it down sufficiently to form the cavity thereof: the wire is thrust backwards and forwards, to prick the tube completely into the bowl; it is then wholly withdrawn, the parts of the mould separated, and the pipe taken out, the superfluous clay removed with a knife, and they are laid up to dry a day or two, after which they are scraped and polished with a piece of hard wood, the tubes of the pipes curved as they are intended to be, and they are then carried to the furnace to bake, which is done in seven or eight hours for fifty gross of pipes. This furnace is fully described at the end of our article Furnace.

The Turks use pipes of three or four feet in length, made of rushes, or of wood, bored at the end; they have a bowl or pot of baked earth to contain the tobacco, which they separate from the tube when they leave off smoking. To make the tube tight, some kinds are made of spiral wire covered with leather. This at the same time leaves them flexible, and the bowl can stand on the ground, whilst the smoker inhales its fumes through an ivory or silver mouth-piece at the end of the tube. Of this kind is the *hookah*, or *houkar*, used by the luxurious East Indians; it is a complete furnace or chafing-dish, with grate-bars, ash-pit, &c.; and has a tight cover over the top, with one of these flexible pipes attached to it. An officer of the court of a petty eastern prince is called *houkar boudar*, and is solely employed in managing this machine; which, having lighted and prepared, he presents the mouth-piece of the tube to his master after his dinner. In some instances, the bowl is kept in an adjacent closet, the pipe being conducted through a hole in the wall. Some of those which are most complete have another peculiarity; the smoke, before it goes into the tube, is made to pass under water, by bubbling up through it. This is found to give the smoke a mild and agreeable flavour, by depriving it of its acrid and pungent taste; and, indeed, it is for the same end of condensing these particles, that the tubes are made of such great length. We are not informed how the smoke is made to pass under the water, but have seen a simple experiment, which any one may try, to experience the improvement of the smoke by this process. Procure a common decanter or glass bottle, fill it half full of water, and fit a cork to it, which has two holes made through it by burning, sufficiently large to admit tightly the tube of a tobacco pipe: in one of the holes fit a pipe with a bowl, the tube end projecting so far down into the bottle, that it will be an inch below the surface of the water: into the other hole, fit a pipe without a bowl, not reaching to the water, but sufficiently curved or inclined to come conveniently to the mouth. Make all the joints tight by wax, fill the bowl of the pipe with tobacco, and light it; then by sucking air through the mouth-pipe, it will be drawn out of the bottle, and rarefy that within; the atmospheric air then presses through the burning tobacco in the bowl of the pipe, and carries the smoke down the tube through the water, and it rises in bubbles to the surface of the water in the bottle, from whence it can be inhaled through the mouth-pipe, by continuing to suck at it. The smoke is by this process cooled, and rendered very agreeable, by the separation of certain principles which are of a very unpleasant flavour: the existence of these principles will be shewn by the water in the bottle becoming yellow in a short time, and having a very disagreeable taste. This method of smoking may be useful to invalid smokers, who from cough, or inflammation of the lungs, are unable to continue a practice which, by long habit, has become quite an essential comfort to them.

Pits

Pits, *Brine*, the name given by the people of Worcestershire and Cheshire, to the wells or pits affording the salt water, out of which they extract the salt.

These waters, though they all contain salt, yet have other things also in them, and these not in small quantity. They all contain a very large proportion of stony matter: this is common to the whole set, but particular substances beside

this are found in the particular pits. At Northwich, in Cheſhire, there are four pits, the water of which ſtinks very ſtrongly of ſulphur, and contains ſo much vitriol, that it will turn black like ink, with a decoction of galls: yet this is boiled into a very fine and pure kind of ſalt, common at our tables under the name of baſket-ſalt, and having no ſuch properties.

There is a vaſt quantity of ſtony matter precipitated from theſe pans of brine, in the boiling of them to ſalt: this is partly ſaved in ſmall pans ſet at the ſide of the boiler, and partly precipitates to the bottom of the pan, where it forms a cruſt like that at the bottom and ſides of our tea-kettles, which the workmen find it neceſſary to remove every week; but there is no vitriol or ſulphur ſeparated. Phil. Tranſ. N° 150.

In the country near where theſe brine-pits are, the inſtruments uſed in boring often bring up fine and hard ſalt; ſo that they give proofs of there being rocks of ſalt in many places.

All along the river Weever, on each ſide, the earth affords brine wherever it is opened; but all theſe are not fit for boiling, many of the pits affording a brine too weak to be worked to any advantage. The very ſtrongeſt pits ſometimes alſo become at once too weak: this is owing to the irruption of freſh ſprings into them, and ſometimes the river itſelf makes its way into them, and overflows them with ſuch a quantity of freſh water, that they are utterly ſpoiled. The brine-pits at Weſton, near Stafford, afford a brine that ſtinks like rotten eggs: this turns inſtantly to ink with galls, and purges and vomits violently, if taken even in a ſmall quantity. This, in boiling, depoſits a white flaky ſand, or ſtony matter, without ſmell or taſte, and the ſalt is pure and fine.

The pit at Droitwich, in Worceſterſhire, affords no ſand in the boiling, nor any the leaſt ſediment of the ſtony matter at the bottom of the pan, and the ſalt is the pureſt of all the others; and by the people of the country it is eſteemed the moſt wholeſome, becauſe of its being without the ſand.

This and the other pits hereabout, all have the ſmell of rotten eggs, eſpecially after a little reſt, as on the Monday morning after the Sunday's reſt. If meat be put to pickle in the brine of theſe pits, inſtead of being preſerved, it will ſtink in twenty-four hours, ſometimes in twelve, yet they yield the beſt ſalt of any inland pits in the world.

The ſulphur ſpaws of Yorkſhire, which are very numerous in different parts of the county, all ſtink violently of rotten eggs; but if well drawn and worked, they would prove as inoffenſive as the reſt, and only ſo many weaker or ſtronger brine pits; and the ſmell is no other than that of the Cheſhire and Staffordſhire brine, when it has been left ſome time at reſt. It is remarkable, that though the ſtony matter is depoſited in ſuch vaſt plenty by the waters of all our ſalt ſprings, it is not found in any abundance in thoſe places where ſalt is made out of ſea-ſand, as in Lancaſhire, and ſome other places; ſo that it is much more than the natural quantity of ſpar contained in water that is thus depoſited; and indeed it appears from trial, that the brine of our ſalt ſprings, in general, contains more than twenty times the quantity of ſpar that common water does.

This ſtony matter ſeparates itſelf from the water before the ſalt does, and thus it appears in many other waters impregnated with mineral particles. The vitriolic waters all contain ochre and ſalt, and in all theſe the ochre ſeparates itſelf firſt in the boiling, and then the vitriol; and the ſtony matter precipitated from common ſalt ſprings affords, on an analyſis, the ſalt called *nitrum calcareum*, in conſiderable abundance. Phil. Tranſ. N° 156. See Salt.

Pits, *Forcing*, in *Gardening*, ſuch as are formed and conſtructed on ſomewhat ſimilar principles to thoſe in hot-houſes, ſtoves, &c., and which are found of very great uſe and advantage in raiſing crops of culinary exotics, as cucumbers, and many other ſorts;—in forcing common vegetables, as aſparagus;—in raiſing young exotics, as pines and other plants;—or in producing grapes. For theſe general purpoſes, pits have been conſtructed with one ſingle fire, which are capable of producing four different temperatures of heat at the ſame time. They are, conſequently, able to force all kinds of common vegetables, and capable of growing vines, pines, and melons, each in their proper climate, with one fire, and little trouble or expence. See Hot-house and Stove.

Pit-*Coal*. See Coal.

Vegetables have been conſidered as the materials for the formation of pit-coal; but M. Chaptal obſerves, that a few foreſts, being buried in the earth, are not ſufficient to form the mountains of coal which exiſt in its bowels. He thinks ſome proviſion, greater and more proportioned to the effect, is requiſite, and this he finds only in the prodigious quantity of vegetables which grows in the ſeas, and which is ſtill increaſed by the immenſe maſs of thoſe that are carried down by rivers. Thoſe vegetables carried away by the currents, are agitated, heaped together, and broken by the waves; and afterwards become covered with ſtrata of argillaceous or calcareous earth, and are decompoſed. It is eaſier to conceive how theſe maſſes of vegetables may form ſtrata of coal, than that the remains of ſhells ſhould form the greater part of the globe. In confirmation of this theory, Chaptal alleges, the preſence of vegetables in coal mines; the impreſſions of ſhells and of fiſh that are found in the ſtrata of coal, and not unfrequently ſhells themſelves; and alſo the evidence afforded by the nature of the mountains which furniſh coal, from which it appears that their formation is ſub-marine; for they all conſiſt either of ſchiſtus, or grit, or limeſtone. The ſecondary ſchiſtus is a kind of coal, in which the earthy principle predominates over the bituminous. As the origin of the ſchiſtus, on which the texture of the vegetable, and the impreſſion of fiſh are well preſerved, is ſub-marine, the ſame muſt likewiſe be the origin of the coal diſtributed in ſtrata through its thickneſs. The grit-ſtone conſiſts of ſand heaped together, carried into the ſea by rivers, and thrown up againſt the ſhores by the waves. The ſtrata of bitumen which are found in theſe cannot but come from the ſea. Calcareous earth rarely contains ſtrata of coal, but is merely impregnated with it; the bitumen forming a cement with the calcareous earth.

Pit-coal is uſually found in ſtrata in the earth, almoſt always in mountains of ſchiſtus or grit. The ſecondary ſchiſtus is the baſis of all pit-coal, and the quality of the coal moſtly depends upon the properties of this baſis. When the ſchiſtus predominates, the coal is heavy, and leaves a very abundant earthy reſidence after its combuſtion. As the formation of the pyrites, as well as that of coal, ariſes from the decompoſition of vegetable and animal ſubſtances, all pit-coal is more or leſs pyritous; ſo that we may conſider pit-coal as a mixture of pyrites, ſchiſtus, and bitumen. The different qualities of coal, therefore, ariſe from the difference in the proportion of theſe principles. When the pyrites is very abundant, the coal exhibits yellow veins of the mineral, which are decompoſed as ſoon as they come in contact with the air; and form an effloreſcence of ſulphat of magneſia, of iron, of alumine, &c. When pyritous coal

is ſet on fire, it emits an inſupportable ſmell of ſulphur; but when the combuſtion is inſenſible, inflammation is frequently produced by the decompoſition of the pyrites; and it is this which occaſions the inflammation of ſeveral veins of coal. When the ſchiſtus, or ſlaty principle, predominates in coals, they are then of a bad quality, becauſe their earthy reſidue is more conſiderable. The beſt coal is that in which the bituminous principle is the moſt abundant, and exempt from all impurity. This coal ſwells up when it burns, and the fragments adhere together; it is more particularly upon this quality that the operation called deſulphurating or purifying of coal depends. This operation is analogous to that in which wood is converted into charcoal. In the deſulphuration, pyramids are made, which are ſet on fire at the centre: when the heat has ſtrongly penetrated the maſs, and the flame iſſues out of the ſides, it is then covered with moiſt earth; the combuſtion is ſuffocated, the bitumen is diſſipated in ſmoke, and there remains only a light ſpongy coal, which attracts the air and humidity, and exhibits the ſame phenomena in its combuſtion as the coal of wood. When it is well made, it gives neither flame nor ſmoke; but it produces a ſtronger heat than that of an equal maſs of native coal.

It was long ſuppoſed that the ſmell of pit-coal is unwholeſome; but the contrary is now proved. M. Venel has made many experiments on this ſubject, and is convinced that neither men nor animals are incommoded by this vapour. Mr. Hoffman relates, that diſorders of the lungs are unknown in the villages of Germany, where this material of combuſtion is only uſed. Coal of a good quality, it is ſuppoſed, does not emit any dangerous vapour: but when it is pyritous its ſmell muſt be hurtful. The uſe of coal is generally applicable to the arts in a variety of ways. In Scotland lord Dundonald has erected furnaces in which the bitumen is diſengaged from coal, and the vapours are received and condenſed in chambers, by means of water, and theſe condenſed vapours afford an ample ſupply of tar. M. Faujas has carried into execution a ſimilar proceſs at Paris, by ſetting fire to coal, and extinguiſhing it at the proper time, ſo that the vapour may paſs into chambers containing water for the purpoſe of condenſing them. This tar is ſaid to be ſuperior to that of wood. (See TAR.) Pit-coal likewiſe affords ammoniac by diſtillation, which is diſſolved in water, while the oil floats above. When coal is deprived by combuſtion of all its oil and other volatile principles, the earthy reſidue contains the ſulphats of alumine, iron, magneſia, lime, &c. Theſe ſalts are all formed when the combuſtion is ſlow; but when it is rapid, the ſulphur is diſſipated, and there remain only the aluminous, magneſian, calcareous, and other earths. The alumine moſt commonly predominates. Chaptal's Elem. of Chemiſtry,

Pitch

PITCH, in the *Arts*, a refinous fubftance, which is the refiduum of the diftillation of tar. Refin differs from pitch in being the refiduum of turpentine, which is obtained from the different fpecies of pine without heat. Tar is obtained by cutting the wood into pieces, and expofing it to the heat by a furnace for the purpofe. This accounts for the blacknefs of the latter, arifing from the decompofition of the effential oil by heat. Hence the fpirit of tar differs from the fpirit of turpentine merely in colour, from the prefence of carbonaceous matter. See TAR and TURPENTINE.

Pitch is properly a juice of the wild pine, or pitch-tree; and is conceived to be no other than the oil thereof infpiffated, and turned black, farther than in the balfam. For the method of procuring it from the wood of this tree, fee PINE. See alfo TURPENTINE.

The beft is that brought from Sweden and Norway. Its goodnefs confifts in its being of a gloffy black colour, dry, and brittle.

This is lefs pungent and lefs bitter than the liquid tar, (fee TAR,) and ufed only in fome external application, as a warm, adhefive, refinous fubftance. Neumann obferves, that when melted with oils, refins, and fats, into ointments and plafter, the pitch is very apt to feparate and precipitate. The ancients had a peculiar kind of pitch called *brutia*, which was infpiffated to a higher than ordinary degree for certain ufes; fuch as the receiving a proper quantity of bees' wax, to render it the zopiffa ufed in coating the bottoms of fhips; which the common pitch could not do, being of too foft a confiftence for this ufe. Pliny tells us that it was made in this manner: the wood was cleaved and formed into a pile, with proper trenches cut in the earth to receive what run from it in burning. When the pile was lighted, the firft thing that flowed into thefe trenches was a thin fluid liquor like water. Lamp black is the foot of burned pitch: and it is likewife prepared by collecting the foot of pit-coal. See *Lamp* BLACK.

PITCH, *Burgundy*, is brought to us from Saxony, and is fuppofed to be a preparation of the fame kind with the common refin of the fhops, only lefs divefted of the oil, made by boiling the common turpentine till it acquires a due confiftence. Upon making an incifion into the bark of the "Pinus abies," or Norway fpruce fir-tree, a clear tenacious fluid iffues, which concretes into a refinous fubftance, known by the name of "refina abietis." This, after being boiled in water, and ftrained through a linen cloth, is called in the Pharmacopeias "Pix Burgundica," or Burgundy pitch. But if the boiling of the native refin is continued till the water is wholly evaporated, and wine vinegar is at this time added, a fubftance of the name of "Colophonium" is formed. The greateft quantity of Burgundy pitch is collected in the neighbourhood of Neufchatel, whence it is brought into this country packed in cafks. A fictitious fort is made in England, and found in the fhops under the title of *common* Burgundy pitch. It may be diftinguifhed by its friability, want of vifcidity and unctuofity, and the odour which characterifes the genuine fort. Burgundy pitch is of a folid confiftence, yet fomewhat foft, of a reddifh-brown colour, and not difagreeable in fmell. It is entirely confined to external ufe, and was formerly an ingredient in feveral ointments and plafters. In inveterate coughs, affections of the lungs, and other internal complaints, plafters of the refin, by acting as a topical ftimulus, are frequently found of confiderable fervice. See PLASTER.

PITCH, *Jews'*. (See BITUMEN.) Jews' pitch, or afphaltes, is black, brilliant; ponderous, and very brittle. It emits a fmell by friction; and is found floating on the water of the lake Afphaltites, or the Dead fea. The afphaltes of commerce is extracted from the mine of Annemora, and more particularly in the principality of Neufchatel. M. Pallas found fprings of afphaltes on the banks of the Sock, in Perfia. Moft naturalifts, fays Chaptal, confider it as amber, decompofed by fire. It liquefies on the fire, fwells up and affords flame, with an acrid difagreeable fmoke. By diftillation it affords an oil refembling petroleum. The Indians and Arabs ufe it inftead of tar; and it is a component part of the varnifh of the Chinefe.

PITCH, *Mineral*. (See BITUMEN.) This is a modification of pretroleum. It is found in France, in Auvergne, at a place called Puits de Lapege, near Allais, over an extent of feveral leagues. The calcareous ftone is impregnated with a bitumen, which is foftened by the heat of fummer, when it flows from the rocks, and forms a very beautiful ftalactites. It forms maffes in the fields; and impedes the paffage of carriages: the peafants ufe it to mark their fheep. This ftone, when rubbed, emits a filthy fmell. Some have afferted that mineral pitch was ufed to cement the walls of Babylon.

PITCH, *Naval*, *pix navalis*, is that drawn from old pines, ranged and burnt like charcoal. This, with a mixture of tow, or beaten cables, ferves for paying over the feams of a fhip's fides and decks, after they are caulked, to preferve the oakum from any wet; and likewife over all the furface of the bottom and wales: to pay the two latter it is foftened with oil.

PITCH, *Naval*, is alfo a denomination given to that fcraped

from off the ſides of old veſſels; and which is ſuppoſed to have acquired an aſtringent virtue, by means of the ſalt water. It ſerves to make plaſters; though it is certain the apothecaries uſually ſubſtitute the common black pitch in its ſtead.

PITCH, *Greek*, or *Spaniſh pitch*, is that boiled in water till it has loſt its natural ſmell; upon which it becomes dry and friable.

The ancients called it *colophony;* from Colophon, a city in Greece, whence great quantities were brought. See COLOPHON, and *Burgundy* PITCH, ſupra.

PITCH, *Oil of*, *oleum picinum*, is an oil procured from pitch, by ſeparating the aqueous matter that ſwims a-top of the melted pitch. This, from the great virtues formerly attributed to it, was alſo called *balſam of pitch*.

PITCH, *Ointment of*, is made by melting tar with an equal weight of mutton ſuet, and ſtraining the mixture whilſt hot: this is uſed ſometimes as a digeſtive, and ſaid to be particularly ſerviceable againſt ſcorbutic and other cutaneous eruptions. See TAR.

PITCH, *Pills of*, are made of tar mixed with ſo much powdered liquorice, or other ſuch powdered matter as is ſufficient to render it of due conſiſtence for being formed into pills. See TAR.

PITCH *of Caſtro*, in the *Materia Medica*, the name given by Boccone and ſome other writers to a thick kind of bitumen, found iſſuing out of the cracks of ſome rocks near the village of Caſtro: from whence it has its name: it is famous in the eccleſiaſtical ſtate for its medicinal virtues.

PITCH, in *Building*, denotes the angle or gable end.

If the length of each rafter be three-fourths of the breadth of the building, the roof is ſaid to be *true* pitch. This is uſed when the covering is of plain tiles.

If the rafters be longer, it is ſaid to be a *high* or *ſharp-pitched* roof; if ſhorter, which ſeldom happens, it is ſaid to be a *low* or *flat-pitched* roof.

If the length of the principal rafters be equal to the breadth of the building, it is called *Gothic* pitch. This is uſed when the covering is of pantiles.

If to rule as a pediment, it is ſaid to be *pediment* pitch. The perpendicular height of this pitch, is equal to $\frac{2}{9}$ths of the breadth of the building. This pitch is uſed when the covering is lead.

Plane

PLANE, a tool uſed by artificers who work in wood, to produce ſtraight, flat, and even ſurfaces upon that material. Almoſt all trades which fabricate articles of wood, employ planes at times; but as joiners make a greater uſe of theſe tools than any others, they are uſually conſidered as joiners' and carpenters' tools. Planes have been, of late years, uſed by ſome artiſts to produce flat ſurfaces in metals. A plane operates to cut off a thin chip or ſhaving from the wood on which it is applied, by the ſharp edge of a ſteel cutter or broad chiſſel, called, very improperly, the plane *iron:* this is fixed in a hole made through a wooden block, called the plane *ſtock*, and the edge of the iron projects a very ſmall quantity through the lower ſide of the ſtock, called the *face* of the plane; the ſurface of which face is made a perfectly true plane. The iron is fixed in an inclined poſition in the hole through the ſtock, by means of a *wedge* driven in before it, to jamb it faſt in the hole, which being wider than the thickneſs of the iron, leaves an aperture before the iron, called the *mouth* of the plane: this is very narrow where it opens in the lower ſide or face, but grows wider as it riſes up through the ſtock; the wedge is alſo cut forked, to allow more room for the ſhavings which the plane iron cuts to paſs up before it through the mouth. When a plane of this kind is applied with its face upon the ſurface of a piece of wood, and preſſed down upon it whilſt it is moved forwards, the edge of the iron penetrates the wood to the depth which it projects through the face, and removes a ſhaving of that thickneſs and the whole breadth of the edge of the iron, the ſhaving turning up before the iron paſſes through the mouth, and eſcaping. The inclination of the iron makes it cut eaſily; and if the iron is *ſet fine*, that is, if the edge projects but very little beyond the face, it will remove very thin ſhavings, and produce a flat and ſmooth ſurface: on the other hand, if it is *ſet rank*, that is, with a conſiderable projection, it will cut away very faſt, producing a flat though rough ſurface, and quickly reducing the wood to its intended thickneſs: if the wood has an irregular ſurface, it ſoon reduces it to a plane, becauſe the face, being flat, will not ſuffer the edge of the iron to deſcend into the hollow places, but removing all the eminences it paſſes over till they are reduced to one level.

This is a general deſcription of ſeveral kinds of planes, which are all known by different names, from their different dimenſions and purpoſes. Joiners uſe the *jack plane*, the *long plane*, *trying plane*, *ſhooting plane* or *jointer*, and the *ſmoothing plane;* all which they denominate *bench planes*, becauſe the wood they are uſed upon is generally laid on the work-bench. They have alſo the *ſtraight block* for ſtraightening ſhort edges, *rebating planes* for forming rebates; others, for the ſame uſe, are called the *moving ſilliſter*, *ſaſh ſilliſter*, and *ſide-rebating plane.* The *plough* is a narrow plane, provided with apparatus to guide it, in moving ſtraight, to plow a groove or trench at any required diſtance from the edge of a board or other piece of wood, and to any depth or width. The *dado grooving plane* is alſo for forming grooves.

There are ſeveral other tools, which, having an iron fitted into a ſtock, are called planes, becauſe they cut in the ſame manner, though, in ſtrictneſs, they are not planes, for they do not make plane ſurfaces; theſe are *moulding planes*, with faces and cutting edges curved, to produce all the varieties of ornamental mouldings, and which are known by the names of *ſnipe's-bills; ſide ſnipe's-bills, beads, hollows* and *rounds, ovoles* and *ogees.* The varieties and different ſizes of theſe form a vaſt number, with which every complete joiner is furniſhed. It is impoſſible to deſcribe the terms applied to theſe tools without figures, as they are arbitrary, though generally known among workmen. The faces of all theſe planes are ſtraight in the direction of their length, but a ſection acroſs the face is the impreſſion or reverſe of the moulding they are intended to make, and the edge of the iron is curved to correſpond with this curve when in its place, but will in reality be a very different figure, becauſe it is inclined to the face of the plane at an angle of about forty-five degrees. Another diſtinction between theſe and the bench planes is, that their mouths do not open ſo as to diſcharge the ſhaving through the ſtock at the top thereof, but the wedge completely fills the hole, and the ſhaving paſſes out ſideways through a hole for that purpoſe; in ſome, theſe apertures are on the right, and in others on the left ſide; in the firſt caſe the ſhaving is ſaid by the workmen to be thrown on the bench, that is, upon the right ſide of the plane; but when the orifice of diſcharge is on the left, and conſequently the ſhaving thrown upon the left, then the plane is ſaid to throw the ſhaving off the bench. The *compaſs plane* is uſed by coach makers, cabinet makers, &c.; it is made with a convex face, formed to an arc of a circle in the direction of its length, and it therefore forms the concave ſurface of a cylinder. The *forkſtaff plane* is ſtraight in the direction of its length, but its face is made concave in its breadth, to the arc of a ſmall cylinder; the edge of the iron is of courſe curved in the ſame manner, and it planes cylindrical ſurfaces. Coopers alſo employ long and heavy planes to form the edges of the ſtaves of barrels; theſe are mounted in an inclined poſition on legs like a ſtool, with their faces upwards, and the ſtave is drawn backwards and forwards upon them.

Planes are ſo neceſſary for all kinds of work, that any who intend to work in wood, ſhould underſtand the ſtructure and the manner of uſing them. The *jack plane* is uſed for taking off the rough and prominent parts from the ſurface of the wood, and reducing it nearly to the intended thickneſs, in coarſe ſhavings or ſlices. The ſtock of this plane is about ſeventeen inches in length, three inches high, and three and a half inches broad; all the ſides are ſtraight and at right angles to each other: the mouth is cut through the ſolid of the ſtock to receive the iron, and hold it at ſuch an elevation, as to make an angle of forty-five degrees with the face of the plane; the iron is a thin metal plate, one ſide conſiſting of iron the other of ſteel; the lower end of the iron is ground to an acute angle off the iron ſide, forming a ſloping part called the baſil of the iron, ſo as to bring the ſteel ſide to a ſharp edge: the wedge which fixes the iron in its place, is

let into two grooves of the fame form, on the fides of the opening or mouth: two fides of the wedge are parallel, and it is forked or cut away in the middle, leaving the fides like two prongs, to fill the lower part of thefe grooves; this allows the fhaving to pafs up without obftruction before the wedge: for the mouth or opening through the ftock muft be uninterrupted from the face to the top, and muft be no wider on the face of the plane, than is fufficient for the thickeft fhaving to pafs with eafe; and as the fhaving is difcharged at the upper fide of the plane, the opening through it muft expand or increafe from the face to the top, fo as to prevent the fhavings from fticking therein. A handle, called the *tote*, is fixed to the upper fide of the ftock, immediately behind the iron; it is formed to the fhape of the hand, and direction of the motion, fo as to produce the moft power in pufhing the plane forward.

A workman in ufing the jack plane, lays the piece of wood on the *bench* parallel to its fides, with the farther end lodged againft the *bench-hook*; then laying the fore-part of the plane upon the hind end of the wood, with the right hand he takes the handle, and preffing with his left upon the fore end, thrufts the plane forward in the direction of the fibre of the wood and length of the plane, until he has extended the ftroke the whole length of his arm, the fhaving being difcharged at the orifice; he then draws back the plane, and repeats the operation in the next adjacent rough part, proceeding in this manner until he has removed the rough parts throughout the whole breadth. He then fteps forwards the diftance of the length he has planed, and operates upon another length in the fame manner, proceeding this way by fteps, until the whole length is gone over and rough planed. To do this is very eafy; but a workman will not make good progrefs nor do clean work, unlefs he has firft adjufted his tool properly for the work. The methods of doing this are nearly the fame for all planes. The firft care is to obtain a fharp cutting edge to the iron; if it requires grinding on the grindftone, the carpenter places his two thumbs under the iron, and the fingers of both hands above, laying the bafil fide to the grindftone, and holding it to the angle he intends it fhall make with the fteel fide of it, keeping it fteady while the ftone revolves; and preffing the iron to the ftone with his fingers; in order to prevent the ftone from wearing the edge of the iron into irregularities, he moves it alternately from edge to edge of the ftone, with fo much preffure on the different parts as will reduce it to the required bevel, and make the edge ftraight.

The bafil being brought to a proper angle, and the edge to a regular and flight curvature, the roughnefs occafioned by the gritty particles of the ftone are taken away by rubbing its edge on a fmooth flat hone or Turkey ftone, fprinkled with olive oil on its furface. As the bafil is generally ground, to give a more acute angle than the edge of the iron would ftand, for the quicker difpatch of wetting it, the face of the iron is inclined nearer to the perpendicular, while it is rubbed backwards and forwards with the fame inclination throughout. Every time the iron becomes dull or blunt by ufe, the fharpening is produced by grinding on the rubber-ftone, or flat grindftone, or on a Turkey ftone; but in repeating this, after the edge gets thick, it requires fo much time to bring it up to an edge, that recourfe muft be had to the grindftone. The iron being thus fharpened, muft be fixed in the plane by its wedge: the projection of the cutting-edge muft be juft fo much beyond the face of the plane, as that the workman may be able to work it freely in the act of planing, and muft be regulated by the ftuff to be wrought; whether it is hard or foft, crofs-grained or curling; fo that a man may be able to perform the moft work, or reduce the fubftance moft in a given time. If the ftuff is good and clean-grained, it is evident that a confiderable projection may be allowed, as a thicker fhaving may be taken: the extreme ends of the edge of the iron muft never enter the wood, as this not only retards the progrefs of working, but choaks and prevents the regular difcharge of the fhavings at the orifice of the plane. The projection of the cutting-edge is called *iron*, and the plane is faid to have more or lefs iron, as the projection is greater; when there is too much iron he knocks with a hammer on the fore end of the top of the ftock, and the blows will loofen the wedge, and raife the iron in a certain degree, and the head of the wedge muft be knocked down to fix it again.

When he has occafion to take out the iron to fharpen it, he ftrikes the fore end of the top of the ftock fmartly with the hammer, which loofens the wedge and the iron.

All the other bench planes are adjufted in the fame manner, and indeed do not differ, except in dimenfions, as we fhall explain, from the jack plane. Of late years, a great improvement has been introduced in the irons of planes, to caufe them to cut fmooth; thefe are called double ironed: they were at firft only ufed in the fineft fhooting planes, but the advantages have been found fo great, particularly in planing bad wood, that they have become general for all forts of planes. The double iron confifts of a fecond iron, with a reverfed bafil fcrewed againft the front fide of the iron, fo that its edge lies againft the iron at a very fmall diftance from, and parallel to, the cutting edge; and applying clofely to the fteel fide of the iron, it forms an inclined plane, which turns the fhaving over immediately after it is feparated or cut up by the edge, and thus it prevents the iron from fplitting the fhaving deeper down than it will afterwards cut, and therefore leaving a rough or torn furface. This fecond iron is called the cover of the iron; and the bafil of its edge, inftead of being ground flat, as that of the iron, is rounding: the fcrew, which binds the cover upon the iron, paffes through a flit in the cover, and thus admits of its edge being adjufted at any required diftance from the cutting edges of the iron, and this diftance depends altogether on the nature of the wood the plane is to be worked upon. If the ftuff is clean-grained, the edge of the cover may be fet at a confiderable diftance, becaufe the difficulty of pufhing the plane forwards becomes greater, as the edge of the cover is nearer the edge of the iron, and the contrary when more remote: this is occafioned by the edge of the cover turning the fhaving over immediately it is cut up.

The *trying plane* is ufually twenty-two inches long, three-quarters broad on the face, and three in height; it does not differ from the jack plane, except in having a double handle, adapted for greater force: in ufe, it fucceeds the operation of the jack plane, to ftraighten the wood, and remove the ridges left by the former; it is fet with lefs iron, and cuts a finer fhaving: the mouth is alfo much narrower. When it is ufed upon a long piece of work, the workman takes every fhaving the whole length, by ftepping forwards, inftead of ftopping at arm's length, as with the jack plane. The fhaving of this plane, though finer, is fo much broader than the jack, that it requires as much force to pufh it forwards.

The *long plane* is fet very fine for finifhing work which is to be very ftraight; it is twenty-fix inches long, three and a half broad, and three inches in height.

The *fhooting plane*, or *jointer*, is the longeft, and moft correct plane ufed; it is employed after all the others, chiefly in fhooting the ftraight edges of boards which are to be jointed together; it is generally made two feet and a half

long, three inches and a quarter broad, and three and a half high; it is used like the others, but with great care to move it steadily from one end of the work to the other, without pressing it down, as that might spring the plane, or the work, and cause the iron to cut when the work was something hollow, whereas the object is to make a perfectly straight edge. The face of this plane must be kept quite true, and therefore it is a great object to make it of a fine piece of clean-grained, hard beech, well seasoned, that it may not warp, or vary, by the weather.

The *smoothing plane* is very short, without any handle, and its sides are curved, so that it very much resembles a coffin; it is seven inches and a half long, three broad at the mouth, and two inches and three quarters in height; it is used for finishing work when put together, and to give the greatest degree of smoothness to the wood, for which purpose it is set with as fine an edge as possible.

Rebating planes are used for cutting out rebates; these are a kind of semi-grooves upon the edge of a board, or other piece of wood, formed by cutting down or reducing a small part of the breadth of the board to half, more or less, of the general thickness: by this means, if a rebate is cut on the upper side of one board, and the lower side of another, the two may be made to overlap each other, without making them any thicker at the joint. Rebates are also used for ornamenting mouldings, and many other purposes in joiners' work. The planes for cutting them are of different kinds, some having the cutting edge at the side of the iron and of the stock, others at the bottom edge of the iron and the face of the stock, and others cutting in both these directions; the former, being used to smooth the side of the rebate, are therefore called side-rebating planes; whilst the others are used for smoothing the bottom. There is also a third sort, called *fillisters*, used for sinking, or cutting away the edge of the piece of wood to form the rebate, leaving it for the others to smooth the surfaces when cut. The rebate planes are about nine inches and a half long, and of various widths upon the face, from half an inch to an inch and three quarters; in all cases they have the mouth and the edge of the iron coming out at one edge of the face, and the side of the iron also exposed at one of the upright sides of the stock, whether it is formed with a cutting edge there or not: this exposed side is either on the right or left, and they are named accordingly. In all cases they throw the shaving out on the side, instead of at the top of the stock. The cutting edges and mouths are generally situated obliquely across the face, instead of being at right angles to the length of the plane, as in others.

The *moving fillister* is a rebating plane, which has a ruler of wood, called the *fence*, fixed upon its face by screws in the direction of its length, and exactly parallel to the edge of the face; it therefore covers part of the length of the cutting edge, and can be fixed at any required distance from the edge, to leave more or less of the cutting edge exposed, and this quantity will be the breadth of the rebate it will cut; because when it is used, the edge of the fence is applied against the edge of the piece to be rebated, and thus gauges the breadth its iron shall cut away. The cutting edge of this plane is not situated at right angles to the length of the stock, but has an obliquity of about forty-five degrees, the exposed side of the iron being more forwards than the other. By this obliquity, when the plane is worked, it has a tendency or drift to run farther into the breadth of the wood, but as the fence, sliding against the edge, prevents this, the drift always keeps the fence in contact with the edge, without the attention of the workmen; it also causes the iron to cut the bottom of the rebate smoother, particularly in a transverse direction to the fibres, or where the stuff is cross-grained, than could otherwise be done, when the steel face of the iron is perpendicular to the vertical sides of the plane. The principal use is, however, to contribute, with the form of the cavity, to throw the shaving into a cylindrical form, and thereby making it issue from one side of the plane. The iron is what is called shouldered, that is, the lower part or shoulder where the edge is, has double the width of the upper part, which is received into the mortise, and jambed fast by the wedge. It is the edge of this wide part only which is exposed at the side of the stock. Besides this principal iron, there is another small iron, called the tooth, which precedes the other, to scratch or cut a deep crack at the width of the rebate, thus making the shavings which the iron cuts up from the bottom separate sideways from the rest of the wood. This tooth is inserted in a vertical mortise through the stock, between the fore end of the stock and the iron. The lower end of this little iron is ground with a basil on the inside, so as to bring the bottom of the narrow side of the iron to a very convex edge; it is fastened by a wedge passing down before it in the mortise in the stock. The use of this tooth is principally for cutting the wood transversely when wrought across the fibres, and by this means it not only cuts the vertical side of the rebate quite smooth, but prevents the iron from ragging or tearing the stuff. The iron between the fence and the edge of the face of the plane, must project the whole breadth of the uncovered part of the face, otherwise the wood of the plane will bear it up, and prevent the plane sinking as it cuts away the rebate, and the edge of the tooth or little iron should stand out a little farther on the side of the plane than the iron. The depth of the rebate which this plane will cut, is regulated by a stop fixed on the outside of the plane, at the intended height above the level of the face: then, when the plane has penetrated or sunk the intended depth of the rebate, the stop comes to bear upon the solid of the wood beyond the rebate, and bears it off from cutting any longer. The stop is a piece of brass, which moves in a vertical groove made in the side of the stock, between the iron and the fore end of the plane; in this it is moved up and down by a screw, which is inserted in a vertical perforation from the top of the plane to the groove, and passing through a part projecting from the stop into the groove: the upper part of the screw is formed to a thumb-nut, to turn it round by, and it is so confined by proper collars, that it can neither move up nor down; but being turned, the inclination of the threads will rise or fall according to the direction in which the thumb-screw is turned, and cause the stop to move up and down in the groove on the side of the plane, thus regulating it at pleasure to the depth to which the rebate is required to be sunk.

In grinding and fixing the iron of this plane, it is necessary that the cutting edge of the iron should stand equally prominent in all parts out of the face, otherwise the plane cannot make shavings of an equal thickness; and, consequently, instead of keeping the vertical position, will, as it proceeds, become deeper on the side on which the shavings are thickest, and then the part cut away will not be regular, for the bottom of the rebate will not be parallel to the upper surface of the wood, and the side which ought to have been vertical, will be a kind of a ragged curved surface, formed by as many gradations or steps in the depth as the number of shavings.

The *sash fillister* differs in several particulars from the mov-

ing filliſter: the breadth of the iron is ſomething more than the whole breadth of the ſole, ſo that the extremities of the cutting edge are in a ſmall degree without the vertical ſides of the ſtock: the fence is adapted to be moved to a conſiderable diſtance, not being fixed, as in the moving filliſter, by ſcrews upon the face, but ſuſtained by two bars fixed faſt to it, which paſs through the two vertical ſides of the ſtock, at right angles to the ſides, fitting tight in the two holes through which they paſs; theſe bars are made rounding upon the upper ſide and flat on the lower ſide: at the point where they are united to the fence, they have thicker parts, or ſhoulders, projecting downwards, becauſe it is neceſſary to have the fence fixed on a lower level than the face of the plane: the ends of the bars are ferruled, to prevent ſplitting when the ends are ſtruck with a mallet, in order to move them in the holes through the ſtock, and this brings the fence either nearer or more remote from the ſtock, as may be wanted; and to fix it faſt, when ſo adjuſted, two ſmall tapering pieces of wood, called keys, are inſerted into two ſmall wedge-like mortiſes, cut at the ſides of the mortiſes in which the bars paſs through the ſtem; theſe wedges being drawn in, they will ſtick faſt, and preſs againſt the bars, keeping them faſt at all points, and thereby regulate the diſtance of the fence from the vertical ſide of the ſtock. This plane is generally employed to rebate narrow pieces of wood, ſuch as ſaſh frames; and the fence is applied againſt the oppoſite edge of the wood to that on which the rebate is to be formed.

The *plough* is a plane with a very narrow face, made of iron, fixed beneath a wooden ſtock, and projecting down from the wood of the ſtock, the edge of the iron being the full width, or rather more, than the face; it is guided by a fence with two bars, like the filliſter above deſcribed, to make or plough out a groove of the width of the iron, and at any required diſtance from the edge of the wood; it has alſo a ſimilar ſtop to regulate the depth it cuts to.

Plane for planing ſurfaces of Metal.—This tool has been brought into uſe within theſe few years paſt, to the great improvement of the work of thoſe artiſts who employ it. Theſe are chiefly the mathematical inſtrument-makers who are in the conſtant habit of having to make ſtraight rulers in braſs, and prepare work requiring very flat ſurfaces, ſuch as the limbs of ſextants, &c.; but all trades which work in braſs and iron, would find their advantage in employing the plane. The ſtock of this plane is uſually made of caſt-iron, in form of a hollow box, the bottom, ſides, and ends being all caſt in one piece; it is uſually 12 inches in length, $1\frac{3}{4}$ in height, and $1\frac{1}{2}$ in breadth acroſs the face; the iron is ſituated at about four inches from the fore end, not inclined, as in other planes, but held in a perpendicular direction, with its lower or cutting edge paſſing through the mouth, and projecting the leaſt poſſible quantity beneath the ſurface of the face, but leaving only ſo ſmall a ſpace before the edge for a mouth, as will but juſt admit a piece of thick paper; the iron is held againſt a braſs frame fixed acroſs in the hollow of the box or plane, and containing within it a ſcrew, on which a nut or ſlider is fitted, to riſe and fall when the ſcrew is turned round by a milled head upon the upper end of it; the nut or ſlider has a projecting pin, which enters into a round hole made through the iron; and in this caſe, by turning the ſcrew, the iron is raiſed or depreſſed, to cauſe the edge to protrude more or leſs beyond the face; to ſupport this frame behind, a block of wood is fitted into the hollow of the ſtock, to fill up all the cavity, and it projects ſo much above as to form the handle for the plane.

In the front end of the ſtock a ſcrew is tapped through its thickneſs, and acts againſt a piece of wood, which it preſſes up againſt the iron, and thus holds it faſt againſt the braſs frame, in the ſame manner as the wedge of a common plane; this piece of wood is formed forked and hollowed where it applies to the iron, to allow room for the chips to come up from the mouth. The workmen who uſe this plane call it *ſtriping*, inſtead of planing, braſs or other metal.

The metal plane is uſed in the ſame manner as a carpenter's jack plane, but as the ſhaving it cuts, or rather ſcrapes off, muſt be exceedingly thin, the greateſt nicety is neceſſary in adjuſting the projection of the iron beyond the face; and for this reaſon the ſcrew is eſſential.

The work is to be ſupported upon a firm bench, which is beſt made of caſt-iron, and the ſurface of it made perfectly flat, which is done by grinding the face of the plane againſt it with emery, till both are true. The front face of the iron is quite flat, and perpendicular to the face; the edge is formed at the bottom of this ſurface by grinding a bevel from the back at an angle of about 45 degrees; the edge is then made fine by a Turkey ſtone. The iron muſt be exceedingly hard and of the very beſt ſteel, and then the plane will cut ſoft ſteel, bell-metal, or *caſt-iron*, as well as braſs, to very good purpoſe. When the work is rough, it is difficult for a man to work the plane, if ſet coarſe for expedition, they therefore uſe, in ſuch caſe, an iron which is cut with flutes on the front ſide, and then the edge will be divided into ſeparate teeth, which ſcrape and cut away with leſs reſiſtance than a complete edge. Meſſrs. Holtzapfell and Deyerlien of Cockſpur-ſtreet, make theſe planes for metal of exceedingly hard caſt-iron, and very true faces, which do not therefore become ſcratched or injured by wear. It ſhould have been mentioned before, that joiners, cabinet-makers, &c. in planing thin or valuable woods for veneering, &c. ſometimes uſe fluted irons, having teeth in their edge; and a plane thus mounted is called a *toothing plane;* theſe irons apply to the ſtocks of different planes.

Planing machines

PLANING MACHINES, are machines ufed to diminifh the great manual labour of planing the furface of planks and boards of wood: in ftrictnefs, thofe alone fhould be termed planing machines, which operate to reduce the furface of the wood to a true and fmooth plane, by means of planes or inftruments of a fimilar nature, though actuated by the power of machinery inftead of the ftrength of a man's arm; but cuftom has denominated thofe machines which cut flat furfaces in a different manner from planes by the fame name.

Thefe machines are of modern invention; the firft, we believe, was projected by general Bentham, who obtained a patent for it in 1791. It confifted of a plane, to be put in motion by means of a crank turned by a mill, to give it a reciprocating motion; or on a fmaller fcale it might be worked by hand in the ufual manner, but the plane was fo formed as to require none of the fkill and attention neceffary in the ordinary method of operating: here the workman, befides exerting the force neceffary to force the inftrument along, has feveral points to attend to, even in the fimple cafe of planing a ftraight board he muft adjuft his tool to the board in a proper manner for beginning the ftroke, and employ fufficient force to keep it down to the board; and in returning, he muft raife it up off the board fufficient to fave the cutting edge from injury; he muft alfo guide it fideways to prevent it flipping off the board, and if this is wider than the plane, he muft conftantly examine if he reduces the middle and the fides in a proper manner to make a plane furface; and, laftly, he muft obferve the marks he previoufly makes for the thicknefs of the board, that he may keep it parallel, and not reduce it too thin. By the general's invention all thefe circumftances are gained at once; the plane is made the full width of the boards intended to be planed, and on each fide of it fillets or cheeks are fixed, which project beneath the face of the plane juft as much as the thicknefs the board is to be reduced to: thefe cheeks, therefore, guide the plane fideways in paffing along the board, and gauge it in thicknefs; becaufe, when the board is reduced to the quantity which the cheeks are beneath the furface of the plane, the cheeks reft upon the bench or furface on which the board lies, and bear off the plane, fo that it can cut no longer. The plane is kept down by its own weight, which is increafed, when neceffary, by loading it with weights, and thefe are contrived to be capable of fhifting their pofition from one end of the plane to the other during the time it is making the ftroke; becaufe, at firft the preffure is required at the fore end to enter the cut, but at the conclufion it muft be greateft at the hinder end, to prevent the fore end tripping down the inftant it leaves the board. By another contrivance the plane is caufed to rife up fufficiently to clear the cutting edge from the wood when the plane is on its return. It is by a piece which acts as a handle to the plane, and to which the power is applied, that it is fixed in the manner of a lever upon an axis extending acrofs the width of the plane, and carrying at each fide thereof a fhort lever, provided with rollers in their extremities; the handle projects upwards from the plane, which being forced forwards by it, affumes an inclined pofition, as do alfo the fhort levers, and their rollers then rife above the cheeks of the plane; but when the plane is drawn back, its handle is firft drawn back into an erect pofition, and the levers moving with it, their rollers project beneath the cheeks of the plane, and raife it off the bench, the plane being in its return borne by them.

The bench for fupporting the board during the operation was alfo of a peculiar conftruction, in order to confine the work fteady upon it. In cafes when the boards to be planed are winding or irregular on the lower fide, fo that they cannot lie flat upon the bench, it is provided with two fides, which can be brought to clofe upon the edges of the board, and hold it fteady between them, being furnifhed with one or more rows of flat teeth to penetrate the wood and retain it; thefe fides are contrived to rife or fall upon the bench, to accommodate the different thickneffes of the boards. When a very thin board is to be planed, it might be liable to fpring up to the iron, fo as to be reduced even after the plane came to reft with its cheeks upon the bench; to avoid this the edges of the board are to be held by the fides to the bench above-mentioned, but as it would ftill be liable to fpring up in the middle part, heavy rollers, or rollers loaded with weights, are fitted in apertures made in the plane as near as poffible to the cutting edge, and thefe will keep the board down clofe upon the bench. For planing pieces of greater thicknefs at one end than the other, the cheeks of the plane are to be borne upon rulers of wood laid on the bench on each fide, the wood being as much thicker at one end as the board is intended to be thinner at that end; therefore, when the plane has reduced the wood, the cheeks come to bear upon thefe rulers, and caufe it to move not parallel to the bench, but inclined, according as they are thicker at one end than the other: in like manner, by ufing them of different thickneffes at the different fides the boards may be made feather-edged.

Mr. Bramah invented a planing machine, which he has

ufed very advantageoufly for planing all kinds of timber flat, at an exceedingly fmall expence. In 1802 he took out a patent for the invention, which he defcribes in his fpecification to confift in the following particulars. "The cutting tools employed to reduce the wood, inftead of being worked by hand are to be fixed on frames, fome of which are moved in a rotatory direction round an upright fhaft, and others have a fhaft lying in a horizontal pofition like a common lathe. In other inftances, the tools are fixed on frames, which flide in ftationed grooves to be driven alfo by machinery. The principal points on which the merits of the invention reft are, 1. The materials to be wrought are made to flide in contact with the tool, inftead of the tool being carried by the hand over the work in the ufual way. 2. The tool is made to travel acrofs the work in a fquare or oblique direction, except in cafes where it may be neceffary to fix the tool in an immoveable ftation, and caufe the work to fall in contact with it by a motion. 3. Inftead of common tools, bent knives, fpoke fhaves, or deep cutting gouges, are ufed for cutting off the roughest parts, and planes of various fhapes and conftructions, as the work may require, are applied to follow the former in fucceffion, under the fame operation, and which latter I call finifhers. 4. Thefe are fixed on frames which move in cafes, like thofe on which the faws are fixed in a fawing-mill, and in other inftances thefe frames are fixed on a rotatory upright fhaft turning on a ftep, and carrying the frame round in a direction fimilar to the upper millftone for grinding corn, and fometimes the frames turn on a horizontal fhaft, refembling the mandrel of a common turning lathe. The different planes, tools, &c. are fixed in the frames, fo as to fall fucceffively in contact with the wood or other materials to be cut, fo that the cutter or tool calculated to take the rough and prominent part operates firft, and thofe that follow muft be fo regulated as to reduce the material down to the line intended for the furface. Thefe cutter frames muft alfo have the property of being regulated by a fcrew, or otherwife, fo as to approach nearer the work, or recede at pleafure, in order that a deeper or fhallower cut may be taken at difcretion, or that the machine may repeat its action, without raifing or depreffing the material on which they act. 5. When an upright fhaft is ufed, the pivot is to turn in oil, and it may be raifed or depreffed at pleafure, by means of a greater or lefs quantity of the faid fluid being confined between the end of the fhaft and the bottom of the ftep. 6. The materials to be cut muft be firmly fixed on a frame, fimilar to thofe in fawing-mills, on which the timber is carried to the faws. Thefe frames muft be moved in a fteady progreffive manner as the cutter frame turns round, either by the fame power which moves the latter, or otherwife, as may be found to anfwer beft in practice. 7. The motion of the cutter frames muft be under the controul of a regulator, fo that the velocity of the tool, in paffing over the work, may be made quicker or flower as fuch work may refpectively require, to caufe the cutter to act properly to the beft advantage." For this purpofe Mr. Bramah propofes to ufe what he calls a univerfal regulator of velocity, and which he defcribes as follows: "I take any number of cog-wheels, of different diameter, with teeth that will exactly fit each other through the whole; fuppofe ten, or any other number, but for an example fay ten, the fmalleft of which fhall not exceed one inch in diameter, and the largeft fuppofe ten inches in diameter, and all the reft to mount by regular gradation in their diameters from one to ten. I fix thefe ten wheels, faft and immoveable, on an axis perfectly true, fo as to form a cone of wheels; I then take ten other wheels, exactly the fame in all refpects as the former, and fix them on another axis, alfo perfectly true, and the wheels in perfect gradation alfo; but thefe latter wheels I do not fix faft on their axes, like the former, but leave them all loofe, fo as to turn upon the faid axes, contrary to the former, which are all fixed. All thefe latter wheels I have the power of locking, by a pin or otherwife, fo that I can at difcretion lock or unite any fingle wheel at pleafure to the axis. I then place the two axes parallel to each other, with the wheels which form the two cones as above defcribed, in reverfe pofition, fo that the large wheel at one end of the cone may lock its teeth into the fmalleft one in the cone oppofite, and likewife *vice verfâ*. Then fuppofe the axis, on which the wheels are permanently fixed, to be turned about all the wheels on the other axis will be carried round with velocities correfpondent to their diameters and thofe of the former, but their axes will not move. Then lock the largeft wheel on the loofe axis, and by turning about the faftened axis, as before, it muft take ten revolutions, while the oppofite wheel performs but one; then by unlocking the largeft wheel, and locking the fmalleft one at the contrary end of the cone in its ftead, and turning as before, the faftened axis will then turn the oppofite ten times, while itfelf only revolves once. Thus the axes or fhafts of thefe cones, or conical combinations of wheels, may turn each other reciprocally, as one to ten, and ten to one, which collectively produces a change in velocity, under an uniform action of the primum mobile, as ten to a hundred; for when the fmall wheel on the loofe axis is locked, and the faft one makes ten revolutions, the former will make one hundred; and by adding to the number of thofe wheels and extending the cones, which may be done *ad infinitum*, velocities may be likewife infinitely varied by this fimple contrivance: A may turn B with a fpeed equal to thoufands or millions of times its own motion; and by changing a pin and locking a different wheel, as above defcribed, B will turn A in the fame proportion, and their power will be transferred to each, in proportion as their velocities reciprocally. Here is an univerfal regulator at once for both power and velocity. In fome inftances I produce a like effect, by the fame neceffary number of wheels made to correfpond in conical order, but inftead of being all conftantly mounted on the axes or fhafts, as above defcribed, they will reciprocally be changed from one axis to the other, in fingle pairs, to match according to the fpeed or power wanted, juft as in the former inftance. This method will have, in all refpects, the fame effect, but not fo convenient as when the wheels are all fixed."

The utility of Mr. Bramah's machine, not lefs than its ingenuity, has induced us to procure drawings of one of them, which he has in conftant ufe in his factory at Pimlico. It is upon exactly the fame conftruction as one he made for the royal arfenal at Woolwich, by which all the timber for gun-carriages, and other fimilar articles, is now planed at a trifling expence, compared with the old method of planing by hand labour. See *Plates* I. and II. *Planing Machine*, where *fig.* 1. is a plan of the whole machine, and *fig.* 2. an elevation thereof; A *a* is a vertical axis, put in motion by a fteam-engine, the power being communicated to it by a pair of bevelled wheels B, one fixed on the vertical fhaft, and the other at the extremity of a horizontal fpindle C, *fig.* 1; fee alfo *fig.* 8. *Plate* II. which has a live and dead pulley upon it at *c*, for the reception of an endlefs ftrap, by which the machine is driven. The fhaft *a* A is for the purpofe of carrying an iron wheel 33, fhewn feparate in *fig.* 3; it has the cutters fixed at the different points 7, 7, 7, 7, of its circumference;

these are six in number at each side, and are formed with cutting edges similar to gouges or scoops (see *fig.* 7.); at the two opposite points, 4 and 5, it has small planes fixed in its rim, as shewn separate in *figs.* 4 and 5: when this wheel revolves, its cuttters will cut away all which projects above the plane of their motion; the wood is carried under them with a progressive motion, upon two moveable carriages E E and E E, one at each side of the wheel, and moving in opposite directions; they traverse upon iron beds, or railways F, F, which are more than double the length of the carriages: these are supported on iron legs, from a foundation of masonry, and well united together by cross pieces D, D, to keep them always in one plane, for upon this circumstance the truth of the planing depends. The pieces of wood to be planed are fixed down upon the carriages at G, G, and held firmly by screw-clamps with proper contrivances; the machine is then put in motion, and at the same time that the wheel is revolving the carriages are both drawn in opposite directions beneath its cutters, which soon clears away the wood to a perfect plane, by making successive strokes obliquely across the wood, and as the carriages advance these strokes proceed in succession from one end of the piece to the other. The gouges 7, 7, act first to chop, or hew away the wood roughly, but to a flat surface, and then the planes 4, 5, follow and reduce it to a smooth plane: this is accomplished by their being placed rather nearer the centre, so that they revolve in a rather smaller radius, and thus act upon the wood after the gouges have finished. We shall now enter more minutely into the details of the machinery: the two carriages E, E, are put in motion alternately, by means of an endless chain H H, which is extended between two horizontal wheels K, I; the centre pin of the latter is fixed in a piece of wood *d*, fitted in a groove formed between the two adjacent rails F, F, on which the carriages run; the slider has a screw *b*, by which it is forced outward, and thus strains the chain between the two wheels so tight, that when the wheel K is turned round, it will draw the chain, which being connected with the carriages beneath, gives them both a progressive motion. The wheel K is fixed upon a short vertical axis, upon the lower end of which is a pinion L, having its teeth engaged with a rack M, attached to the piston-rod of a cylinder 10, situated horizontally on the ground (see also *fig.* 10. *Plate* II.): the piston-rod, M, is fitted through a stuffing-box, *e*, at the end of the cylinder, and the piston, *f*, is fitted accurately to the chamber with leathers, to make it perfectly water-tight: the cylinder is bolted fast down upon the floor framing, as shewn in both figures, and pipes *g*, *h*, enter into it at each end, for the purpose of introducing or returning water, which acts upon the piston *f*, to give it an advancing or retrograde motion, upon the hydrostatic principle invented by Mr. Bramah, and described at the end of our article MACHINERY; see also PRESS, *Hydrostatic.* The steam-engine which gives power to the whole machine also works a small forcing pump, or injector, which is constantly pumping water into an air-vessel, under a great pressure: from this small copper pipes are conducted to the machine, to operate, when required, either in the cylinder 10, or in another, which is the step, or support of the main vertical shaft, and gives the means of raising or lowering it with the wheels and cutters all together, to cause them to reduce the wood upon the bench to any required thickness. The admission of the water into these cylinders is regulated by cocks, situated at one side of the machine, in a position where a person can, at the same time, manage them, and have a complete view of all the machine, to watch its operation. The relative position of these cocks is shewn in *fig.* 8, where that for the service of the cylinder is marked N, and the other for regulating the thickness is marked O, and *i* is the pipe leading from it to the bottom of the cylinder 13; the cocks themselves are shewn on a large scale in *figs.* 11 and 12: the entry pipe, which brings the water from the injector, is here plainly shewn, with two branches leading to the cocks. From the cock N, a passage directly opposite to the entry leads to the waste, or escape-pipe; and on the two opposite sides, at right angles to the former, are pipes *g* and *h*, leading to the front and back of the cylinder: the cock itself has two curved passages through it, which will make communication with any two adjacent pipes of the four; thus, as it stands in the figure, the water from the entry passes to the back of the cylinder, whilst the water contained in the front end is at liberty to escape at the waste pipe. In this situation the piston is moved towards the front end of the cylinder, and turning round the pinion and wheel K, (*figs.* 1 and 2.) moves both carriages in one direction: now by turning the cock N a quarter of a revolution in either direction, the same passages make a different communication, *viz.* from the entry to the front of the cylinder, and from the back to the waste; this throws the action upon the front side of the piston, drawing it to the back end of the cylinder, and moving the carriages in an opposite direction. By turning the cock only ⅛th instead of ¼th, all the four passages are close stopped, and no motion takes place. The other cock, O, is more simple; thus, the entry is on one side, the pipe *i* at right angles to it, and the waste opposite the latter; the passage in the turning part of the cock is made diametrically through it, and another at right angles into it. In the position of the drawing, the pipe, *i*, is open to the waste, and permits the water in the cylinder 13 (*fig.* 8.) to escape; but when the cock is turned round one-fourth, to bring the short passage opposite the pipe *i*, a fresh supply of water will be admitted from the entry into the cylinder 13, or, by turning a little farther, all of them are shut. The cylinder marked 13 (*fig.* 8.) is fixed by screws in the middle of one of the cross bars D; it is accurately bored withinside, and fitted with a piston P, (see also *fig.* 13.) which is packed with leather cups, so that no leakage can take place by the side of it; in the upper side of the piston is a perforation for the reception of a steel pivot, which is fixed in the lower end of the great vertical spindle A, and thus supports its weight as it revolves; the upper end, *a*, of the great spindle is fitted through the centre of the cog-wheel, B, with a fillet, so that it has free liberty to rise and fall, but cannot turn round without the wheel; the wheel itself is supported by means of a cone formed on the lower part of it, and fitted into a socket supported at the top of four iron standards Q, Q, which are erected from the iron framing below, and thus they sustain the axis and wheel very firmly from the same frame as the rails F, F, which support the carriages. At the top of the vertical spindle a shackle, *a*, is fitted, by a pin with a head, inserted into the end of the axis, and retained by a cross pin; by this means the shackle is united to the spindle, to rise and fall with it, but not to revolve with it; a chain is attached to the shackle, and passes over a pulley, as shewn at *m*, in *fig.* 2, and thence to a small pulley *n*; to this is attached a larger wheel, *o*, from which a chain is carried, to suspend a heavy wooden ruler *p*, situated at some distance from the machine, and sliding in a groove; it has divisions shewing inches and parts graduated upon it, which are determined by an index fixed to the wood of the groove. On this scale, those divisions which are marked inches are three times that length, because the wheels *n* and *o* are as three to one in dia-

meter: this scale shews the thickness to which the machine will reduce the wood upon the carriages, the index being so adjusted that it stands at zero of the scale when the wheel 3 3 is lowered down till its cutter cuts the surface of the carriage; then by turning the cock N, the water is very gradually admitted into the cylinder 13, and elevates the piston P, the shaft, and wheel altogether, to any required height above the bench, which is shewn in inches and parts by the scale to very great accuracy; for by the cock being very partially opened, the wheel rises so slowly, that it can be adjusted to the greatest nicety. The wheels *n* and *o* are supported in the floor above the room, as is also the frame for the support of the axis, C, of the live and dead pulley *c*; the endless strap of this pulley is guided through an eye at the end of an iron rod *s*, *fig.* 8, which is joined to a lever T, coming down in reach of the attendant, who also manages the cocks N, O.

The construction of the cutters is shewn in *fig.* 7: here 3 is a section of a part of the rim of the wheel, and *t* an iron clamp screwed fast down upon it, as shewn in *fig.* 3; the clamp has a vertical mortise through it for the reception of the stem of the gouge cutter 7, which is fixed fast therein by a wedge piece and screw *v*: by this means they can all be adjusted till their edges come exactly into one plane, though not quite so deep as the faces of the planes: these are made, as shewn in *figs.* 4 and 5, in iron, being received into an opening in the rim of the wheel, and held fast by two bolts, *w*, *w*, with keys above the surface of the wheel to keep them fast; the plane iron, *x*, is double, and fixed into its place by an iron wedge *y*, formed similar to that of a carpenter's plane.

It only now remains for us to explain the construction of the dogs or claws for holding the work fast down upon the benches E, E; these are of two kinds, some fixed on the outsides of the carriage, and others in the middle, which draw up by screws to hold the wood fast; the carriage is composed of two large beams E, E, *fig.* 9, which is a cross section of it; these are united by proper cross pieces, and run upon the rails F, F, with metal pieces fixed on the lower sides of them. There are also several cast-iron frames fixed across, as shewn by the dark shaded parts *k*; each consists of two cheeks, all formed from one piece, and leaving a groove between them; in this groove a long screw, *l*, is fitted by a collar at one end, and operates upon a slider, 8, fitted into the groove; a dog marked *z*, and bent something like an S, is attached to this slider, and projects above the bench, having a sharp point which penetrates the wood 2 G, and forces it against the other claws, *r*, *r*, fixed on the outsides. When the wood, as G, *fig.* 9, is of small size, another small claw, 9, is applied; this is screwed into a nut of brass, which is fitted into the groove, then a second piece of wood, 2, is applied between it and the dog *z*, to transmit the force of the screw, *l*, to the other one at 9: the outside claws, *r*, are formed on the top of square stems, which are fitted through clamps affixed to the sides of the carriages, as shewn in *fig.* 6, and provided with clamp screws, by which they can be fixed at any required height. The dogs *z* are very simply attached to the nut 8, by being applied upon the flat top surface of it, and one point enters into a small hole made in the fore part of the nut 8; by this means it is simply hooked into its place, and when the screw is turned, it cannot get loose; another advantage is, that the clamp may be reversed, or turned the other way, and then the screw can be employed to hold the wood between *z*, and the claws, *r*, of the opposite side of the carriage. By these means the bench will hold a large piece of wood of the full width of the bench, or by introducing one of the clamps, 9, between each piece, it will hold as many narrow ones as will make up the width, and they will be all planed together to one surface.

The endless chain H, which gives motion to the carriages, is connected with them by means of a piece of wood H, *fig.* 9, projecting down from it, and divided into two halves, between which the chain can be clamped or jambed fast when they are drawn together by a screw 6; therefore, by relieving this screw, the two halves open so much, as to permit the chain to slide freely between them; in this case the carriage will stand still. This expedient is used when it is required to have one carriage disengaged, for, in general, both are used together, in the following manner; suppose both carriages at the ends of their respective rails, the wood is laid upon them, and by the screw 6, which is turned with a winch, it is clamped fast on the chain. If the wood is winding, or irregular, it is made up at first by wedges, till its upper surface is parallel to the bench, and it is then fixed by the screws *l*; the carriages are then engaged with the chain, by turning the handle of the screw 6, which for that purpose comes to the outside. Next the cock O is turned one way or the other, to raise or lower the cutter, till the gauge, *p*, shews it to be at the thickness the stuff is to be planed to. All being thus prepared, the handle of the lever, T, is drawn; this draws the strap upon the live pulley *c*, and puts the machine in motion, and having acquired its full velocity, the same person turns the other cock N, and gently opens it; this puts the carriages in motion, and he can, by regulating the handle of the cock, give it any velocity he wishes; he can bring it up very quick, till the work comes under the cutters, and then move it very slowly, if much wood is to be reduced, or quicker when but little is to be taken off. In this manner the planing is performed from one end of the piece to the other, and the successive strokes of the cutters and planes follow each other so closely, as to leave an even surface, and with only such very slight scores across it, that the least shaving of a smoothing plane afterwards finishes it, from the roughest and most irregular timber which can be found.

In 1803, Mr. Bevans obtained a patent for a machine which we have seen at work for planing (or *sticking*, as the joiners term it) all kinds of mouldings or rebates, and ploughing grooves, as well as forming flat surfaces of small breadth, which it does with very little labour: in this machine, these operations are performed by the planes commonly used for similar purposes, with only such alterations as are necessary to adapt them to the machinery by which they are put in motion with mechanical power instead of human labour; they are to be used either singly, or combined together in any number, according to the width of the boards to be worked at once, and the nature of the work to be done, so as to plane up at one operation such moulding as joiners work up by using several planes successively for the different parts; this is effected by a kind of frame or box, which admits of fixing any number of planes in it, side by side, and at any distance asunder, to form the compound moulding required. The work is fixed fast on a bench, and the box of planes is made to pass over it, in the direction of its length, by a connecting rod communicating at one end with the box or frame containing the planes, and at the other end with machinery capable of affording a reciprocating motion.

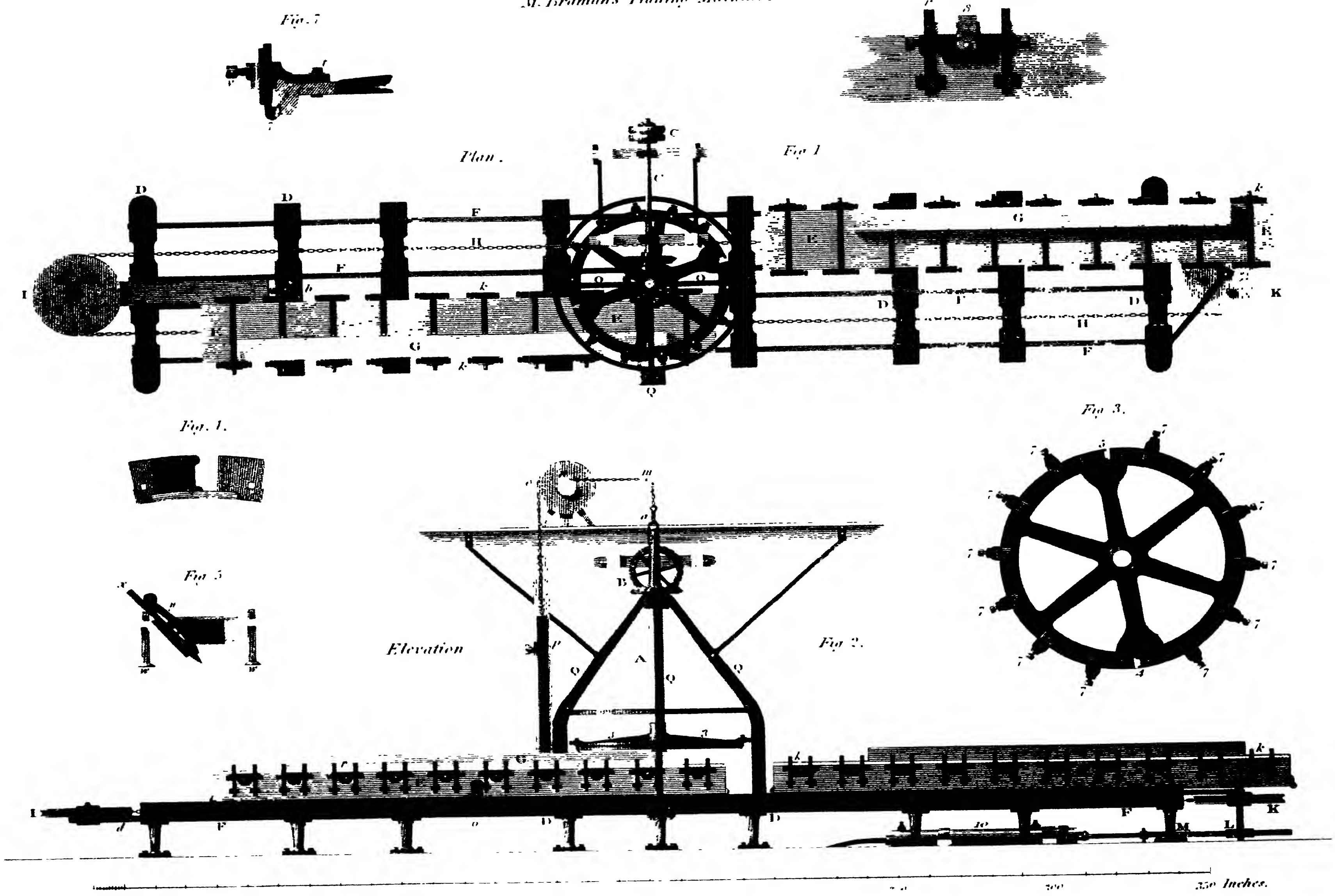
This machinery consists of a crank, whose radius must be nearly half the length of the required stroke, and must be regulated accordingly: this regulation is effected by the arm of the crank passing through a mortise in a strong box, fixed on an axis, and sliding in the said box to any required length, where it must be fixed by strong screws, the axis being turned by manual exertion, by horses, steam, water, or any

other power, and having its motion regulated by a fly-wheel.

The planes are loaded, to keep them in contact with their work, by a long beam of wood, fet up on end upon the fides of the box, and connected therewith by being divided into two cheeks, which at the lower fides are formed to an arc of a circle, and united to the box by chains, in the fame manner as the beams of fteam-engines are connected with their pifton-rods. The upper part of the beam is made to pafs always through one point by fliding between friction-wheels, or otherwife in a tube hung on two pivots perpendicularly over the centre of the work, and at fuch heights as may be moft convenient for the length of the ftroke required: the connecting-rod from the crank before mentioned is jointed to the upright beam, near its lower end, and by this means the motion is given to the box of planes, the chains and arches at the bottom allowing it in all pofitions to preferve the plane horizontal. To guide the box of planes in a rectilinear motion, and alfo to bear them off when they have been reduced to the depth required, fences are ufed, which are irons fliding perpendicularly in tubes or fockets in the box or frame, and clipping a tongue, or ruler fixed in the direction of the required ftroke, in the frame supporting the bench.

PLANING.

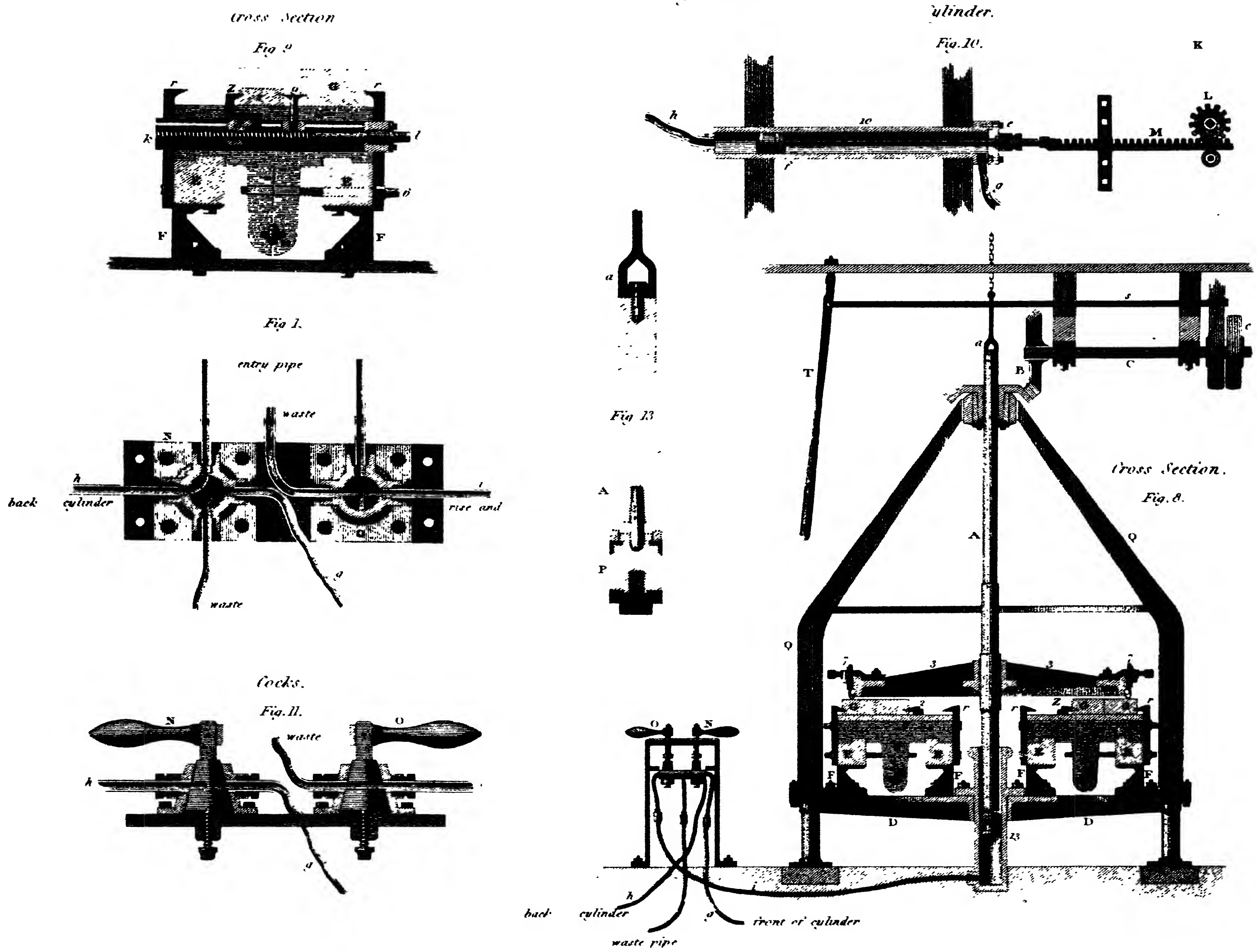
Mr. Bramah's Planing Machine.



PLANING MACHINE.

PLATE II.

Mr Bramah's Planing Machine.



PLASTER, or PLAISTER, in *Building*, a compofition of lime, fometimes with hair, fometimes with fand, &c. to parget or cover the nudities of a building.

There is alfo a plafter of a coarfer fort than the plafter of Paris, which is fometimes ufed in this country for floors in gentlemen's houfes, and for corn-granaries: it is made of a blueifh ftone, taken out of quarries, which are generally at the fide of a hill, much like the ftone of which Dutch terras is made: the ftone is burnt like lime, becomes white by burning, and when mixed with water, does not ferment like lime: when cold, it is beat into a fine powder; and when it is ufed, the quantity of about a bufhel is put into a tub, and water applied to it, till it becomes liquid: in this ftate it is well ftirred with a ftick, and ufed immediately; for in lefs than a quarter of an hour it becomes hard and good for nothing, as it will not bear being mixed a fecond time like lime. See GYPSUM, and PLASTERING.

PLASTER, in *Pharmacy*, an external application of a harder confiftence than our ointments: thefe are to be fpread according to the different circumftances of the wound, place, or patient, either upon linen or leather.

If the part upon which they are to be laid be naturally hairy, it muft be fhaved; but that they may ftick the better, the natural fhape of the part muft be confulted, and the plafter fpread and formed accordingly, either round, fquare, triangular, elliptical, in a lunar form, or in fhape of the letter T. Some alfo are divided at both ends, and others are perforated in the middle: thefe laft are of frequent ufe in fractures attended with a wound; for by this contrivance the wound may be cleanfed and dreffed without removing the plafter.

Indeed there is almoft no part of the body which a plafter of one of thofe forms may not be made to ferve for, if it be notched about the edges with a pair of fciffars. See EMPLASTRUM.

The ufe of plafters is various; they are ferviceable in fecuring the dreffings, they alfo forward the maturation of the pus, agglutinate and heal wounds, unite broken bones, heal burns, affuage pain, and ftrengthen weak parts. In many inftances they contain acrid and ftimulating fubftances, and operate as rubefacients, or blifters.

The calces or oxyds of lead boiled with oils, unite with them into a plafter of a proper confiftence, which makes the bafis of feveral other plafters: but fome of them owe their confiftence to wax and refin; and others contain no oily or fatty matter whatever: in boiling thefe compofitions, a quantity of hot water muft be added from time to time, to prevent the plafter from burning and growing black; but this fhould be done with care, left it caufe the matter to explode.

Plafters fhould not adhere to the hand when cold; they fhould be eafily fpread when heated; and after they are fpread they fhould remain tenacious and pliant; but they fhould not be fo foft as to run when heated by the fkin. All plafters become too confiftent or brittle when long kept; but in this cafe, thofe which are unctuous may be remelted by a gentle heat, and fome oil added to them. They are ufually formed into rolls, each of which is wrapped in paper, and when ufed, they are melted, and fpread on leather, calico, linen, or filk. Thofe that contain metallic oxyds ought to be melted by boiling water, for in a greater degree of heat the fatty matter is apt to reduce the oxyd.

PLASTER, *Adhefive*. See EMPLASTRUM.

PLASTER, *Ammoniac*, is formed by diffolving 5 oz. of purified ammoniac in half a pint of acetic acid (diftilled vinegar), and evaporating the folution in an iron veffel placed in a water bath; conftantly ftirring it till it acquire a proper confiftence. This plafter, which is ftimulant and refolvent, is applied to fcrophulous humours, and white fwellings, and fometimes over the fcalp, in tinea capitis.

PLASTER, *Ammoniac, with Mercury*. See EMPLASTRUM.

PLASTER, *Anodyne*. See EMPLASTRUM, and PLASTER *of Opium*, infra.

PLASTER, *Aromatic*, is formed, according to the directions of the Dublin pharmacopeia, of frankincenfe, 3 oz.; yellow wax, ½ oz.; cinnamon bark in powder, 6 dr.; oil of pimenta and oil of lemons, of each 2 dr. Melt the frankincenfe and the wax together, and ftrain the mixture; when it thickens by cooling, mix with it the powder of cinnamon previoufly rubbed with the oils, and form them into a plafter. This plafter is an elegant ftimulant, and applied to the region of the ftomach in dyfpepfia, and increafed irritability of that vifcus, allays pain and vomiting, and expels flatus. As the oils are very volatile, it muft be fpread by the thumb without being melted. It requires to be frequently renewed, and is not very adhefive.

PLASTER, *Affafœtida*, confifts, by the Edinb. pharm., of plafter of femi-vitreous oxyd of lead, and affafœtida, of each two parts, and galbanum and yellow wax, of each one part. This plafter is fometimes applied over the umbilical region, in flatulence and hyfteria.

PLASTER, *Bliftering*, *Emplaftrum Lyttæ* of the Lond. pharmac., is made by melting 1½ lb. of wax plafter with a pound of prepared lard, and after removing them from the fire, when the mixture is beginning to be folid, fprinkling in 1 lb. of bliftering flies reduced to a very fine powder, and mixing the whole together. The *emplaftrum Meloes veficatorii*, olim, *emplaftrum veficatorium* of the Edinb. pharm., confifts of mutton fuet, yellow wax, refin, and bliftering flies, of each equal weights. Reduce the infects to a fine powder, and mix them with the other articles, previoufly melted together, and removed from the fire. The *emplaftrum cantharidis* of the Dubl. pharmac. is formed by melting purified yellow wax and mutton fuet, of each a pound, and 4 oz. of yellow refin together, and a little before they concrete in becoming folid, fprinkling in 1 lb. of bliftering flies in fine powder, and forming the whole into a plafter. (See EMPLASTRUM.) Bliftering plafters fhould remain applied at leaft for twelve hours to raife a perfect blifter; they are then to be removed, the veficle is to be cut at the moft depending part, and without removing the cuticle, the veficated part is to be dreffed with fimple cerate, or fpermaceti ointment; and the old cuticle allowed to remain until a new one is formed under it; when it peels off, and the whole is healed in the courfe of a few days. The application of thefe plafters is fometimes attended with ftrangury and bloody urine, from the abforption of the active principles of the infect, and the irritation of the kidnies and urethra; and this effect is much increafed, if the blifter be applied over an abraded furface, *e. g.* on the head after it has been immediately fhaved, and alfo if the plafter has remained too long applied. To prevent ftrangury, it has been recommended to mix camphor with the bliftering compofition, but this has no good effect; it is better obviated by copious dilution with milk, or mucilaginous fluids, and fomentations of warm milk and water to the bliftered part, after the removal of the plafter. When the head is to be bliftered, it fhould be fhaved at leaft ten hours before the plafter is applied; and in all cafes it is expedient to interpofe a piece of thin gauze between the veficatory and the fkin, wetted with vinegar, and applied fmooth and very clofe over the

plaster. When the blistered part becomes a spreading sore, which is sometimes the case in irritable habits, the best local application is a warm emollient poultice, and bathing the denuded surface frequently with tepid milk and water; while at the same time cinchona bark is internally administered. See Blister.

Plaster *of Spanish flies, compound*, of Edinb. pharm., is prepared of 18 parts of Venice turpentine; Burgundy pitch and blistering flies, of each 12 parts; yellow wax, 4 parts; subacetite of copper, 2 parts; white mustard seeds and black pepper, of each 1 part. Melt the Burgundy pitch and the wax, and add to them the turpentine; while these remain still warm, after being melted, sprinkle in the other ingredients reduced to fine powder, and mix them, stirring constantly, so as to form a plaster. This plaster is intended to raise a blister more quickly than the former, and is therefore adapted to cases of gout and cramps of the stomach, in which the effect of the blister must be almost instantly produced. Its operation is attended with much pain and pungent sense of heat; and it is apt to produce very unpleasant ulceration if allowed to remain too long applied.

Plaster, *Cephalic*. See Emplastrum *Cephalicum*.

Plaster, *Common*. See Emplastrum *Commune*.

Plaster, *Cumin*. See Emplastrum *è Cymino*. This plaster is stimulant and discutient; and is applied to the hypogastric region in flatulence and a cold feeling of the bowels, and to indolent tumours.

Plaster, *Drawing*. See Emplastrum *Attrahens*.

Plaster *of Galbanum, Compound*, of the Lond. pharm., is composed of purified galbanum, 8 ounces; plaster of lead, 3 pounds; common turpentine, 10 drachms; and resin of the spruce fir powdered, 3 ounces. Having melted the galbanum and the turpentine together, mix in first the resin, and then the plaster of lead previously melted by a slow fire, and mix the whole together. The *plaster of galbanum* of the Dub. pharm. is prepared by adding to ½ lb. of galbanum melted by heat, 2 lbs. of litharge plaster, and 4 oz. of yellow wax sliced; and then melting the whole together by a gentle heat.

Plaster, *Gum*, of Edinb. ph., is composed of 8 parts of plaster of semi-vitreous oxyd of lead, and ammoniac gum-resin, galbanum, yellow wax, of each 1 part. See Emplastrum *Gummi*.

These plasters are stimulant and suppurative. They are applied with advantage to scrophulous tumours; to joints which have been long affected with arthritic pains; and to the loins in rickets. As a suppurative, they are applied to indolent tumours, and to reduce the induration which often remains round abscesses, after they are discharged.

Plaster, *Mercurial*. (See Emplastrum *commune cum Mercurio*.) The Edinb. pharmac. directs it to be prepared of olive oil and resin, of each 1 part; mercury, 3 parts; plaster of semi-vitreous oxyd of lead, 6 parts; rub the mercury with the oil and the resin, previously melted together and cooled, until the globules disappear; then add gradually the plaster of semi-vitreous oxyd of lead melted, and let the whole be carefully mixed together. These plasters are powerful discutients, and are applied to buboes, venereal tumours, nodes when they are not very painful to the touch, and indurations; they are also applied to joints affected with obstinate syphilitic pains.

Plaster *of Opium*, consists of hard opium powdered, ½ oz.; resin of the spruce fir powdered, 3 oz.; lead plaster, 1 lb.: melt the plaster and the resin together, then add the opium, and mix the whole. This plaster is said to be anodyne, and useful in relieving rheumatism and local pains.

Plaster *of red oxyd of Iron* of Edin. pharm., formerly *strengthening plaster*, is composed of plaster of semi-vitreous oxyd of lead, 24 parts; resin, 6 parts; yellow wax and olive oil, of each 3 parts; and red oxyd of iron, 8 parts; rub the red oxyd of iron with the oil, and add the other ingredients melted.

Plaster *of Frankincense* of Dubl. pharm. is formed of litharge plaster, 2 lbs.; frankincense, ½ lb.; and red oxyd of iron, 3 oz.; to the frankincense and plaster melted together add the oxyd, stirring them together so as to form a plaster. These plasters are supposed to be tonic; and are used in muscular relaxations, and weaknesses of the joints after sprains; but they act chiefly in affording a mechanical support to the parts. See Emplastrum *Roborans*.

Plaster, *Compound pitch*, is composed of dried pitch, 2 lbs.; frankincense, 1 lb.; yellow resin and yellow wax, of each 4 oz.; and expressed oil of nutmeg, 1 oz. To the pitch, resin, and wax, melted together, add first the frankincense, then the oil of nutmeg, and mix the whole. This plaster is stimulant and rubefacient. It is used in catarrh, and other pulmonary affections, applied to the thorax; and in head-ache, and chronic ophthalmia, applied to the temples. When a serous exudation takes place, the plaster should be frequently renewed.

Plaster, *Head*, is prepared by boiling together over a slow fire, of semi-vitreous oxyd of lead, rubbed to a very fine powder, 5 lbs.; olive oil, a gallon; water, 2 pints, stirring constantly until the oil and oxyd of lead cohere into the consistence of a plaster. It is necessary, however, to add a little boiling water, if the whole of that which was employed at first shall be consumed before the end of the process.

Plaster *of semi-vitreous oxyd of Lead*, formerly *common plaster*, is prepared of the semi-vitreous oxyd of lead, 1 part; and olive oil, 2 parts; having added some water, boil them, stirring constantly, until the oil and the oxyd unite into a plaster. See Emplastrum.

Plaster, *Litharge*, of Dub. ph., is prepared by mixing 5 lbs. of litharge in fine powder; 9 lbs. of olive oil, and 2 pints of boiling water, at a high temperature, constantly stirring until the oil and the litharge unite so as to form a plaster, supplying occasionally any waste of water that may take place. These plasters are intended chiefly to defend excoriated surfaces from the action of the air, and to form the basis of some other plasters.

Plaster, *Resin*, is formed of yellow resin, ½ lb., and lead plaster, 3 lbs.; melt the lead plaster by a gentle heat; then add the resin in powder and mix.

Plaster, *Resinous*, formerly *adhesive plaster*, is composed of plaster of semi-vitreous oxyd of lead, 5 parts, and resin, 1 part.

Plaster *with Resin, Litharge*, is formed by melting 3½ lbs. of litharge plaster by a moderate heat, and adding ½ lb. of yellow resin finely pulverized, that it may melt quickly, and form a plaster. (See Emplastrum *Adhesivum*.) These plasters are defensive, adhesive, and gently stimulant; they are used for retaining together the lips of recent wounds, when it is proposed to heal them by the first intention; to give support to ulcerated parts; and to assist their granulation and cicatrization.

Plaster, *Soap*. (See Emplastrum *Saponis*.) The *soap plaster* of the Edinb. pharm. is composed of 4 parts of semi-vitreous oxyd of lead; 2 parts of gum plaster, and 1 part of soap sliced. Mix the soap with the plasters melted together; then boil them a little so as to form plaster. Soap plaster is discutient, and is applied to lymphatic tumours; but it is much less useful than the mercurial plaster.

Plaster, *Stomachic*. See Emplastrum *Stomachicum*.

Plaster, *Warm*, is made by melting together, over a gentle fire, one ounce of gum plaſter, and two drachms of bliſtering plaſter; or one part of plaſter of cantharides, and ſeven parts of Burgundy pitch, according to the Dublin pharmacopeia. This is uſeful in catarrh, hooping-cough, the ſciatica, and other fixed pains of the rheumatic kind. It ought, however, to be worn for ſome time, and to be renewed, at leaſt, once a week.

Plaster, *Wax*, is formed by melting together of yellow wax and of prepared ſuet, of each three pounds; and yellow reſin a pound; and then ſtraining. The *ſimple plaſter*, formerly *wax plaſter* of Edinburgh pharmacopeia, is formed of yellow wax, three parts; mutton ſuet and reſin, of each two parts. Theſe were generally uſed inſtead of the melilot plaſter, as a proper application after bliſters, and in other caſes where a gentle digeſtion is neceſſary; but on account of the pain and irritation they occaſion, they are now ſeldom employed.

Plaster *of Paris*, is a foſſile ſtone, ſerving many purpoſes in building; and uſed likewiſe in ſculpture, to mould and make ſtatues, baſſo relievos, and other decorations in architecture.

It is dug out of quarries, in ſeveral parts of the neighbourhood of Paris; whence its name. The fineſt is that of Montmartre. See Gypsum.

Plaſter of Paris, among our workmen, is of two kinds, *viz. crude*, or in the ſtone, and *burnt*, or beaten.

The *crude* is the native plaſter, as it comes out of the quarry; in which ſtate it is uſed as ſhards in the foundations of buildings.

The *burnt* plaſter is a preparation of the former, by calcining it like lime in a kiln or furnace, and then beating it into powder, and diluting and working it. In this ſtate it is uſed as mortar, or cement, in building.

This, when well ſifted, and reduced into an impalpable powder, is uſed alſo to make figures, and other works of ſculpture; and is, beſides, of ſome uſe in taking out ſpots of greaſe, &c. in ſtuffs and ſilks.

The method of repreſenting a face truly in plaſter of Paris is this: the perſon, whoſe figure is deſigned, is laid on his back, with any convenient thing to keep off the hair. Into each noſtril is conveyed a conical piece of ſtiff paper, open at both ends, to allow of reſpiration. Theſe tubes, being anointed with oil, are ſupported by the hand of an aſſiſtant; then the face is lightly oiled over, and the eyes being kept ſhut, alabaſter freſh calcined, and tempered to a thinniſh conſiſtence with water, is by ſpoonfuls nimbly thrown all over the face, till it lies near the thickneſs of an inch. This matter grows ſenſibly hot, and in about a quarter of an hour hardens into a kind of ſtony concretion; which being gently taken off, repreſents, on its concave ſurface, the minuteſt part of the original face. In this a head of good clay may be moulded, and therein the eyes are to be opened, and other neceſſary amendments made. This ſecond face being anointed with oil, a ſecond mould of calcined alabaſter is made, conſiſting of two parts joined lengthways along the ridge of the noſe; and herein may be caſt, with the ſame matter, a face extremely like the original.

If finely powdered alabaſter, or plaſter of Paris, be put into a baſon over a fire, it will, when hot, aſſume the appearance of a fluid, by rolling in waves, yielding to the touch, ſteaming, &c., all which properties it again loſes on the departure of the heat; and being thrown upon paper, will not at all wet it, but immediately diſcover itſelf to be as motionleſs as before it was ſet over the fire; whereby it appears, that a heap of ſuch little bodies as are neither ſpherical, nor otherwiſe regularly ſhaped, nor ſmall enough to be below the diſcernment of the eye, may, without fuſion, be made fluid, barely by a ſufficiently ſtrong and various agitation of the particles which compoſe it; and, moreover, loſe its fluidity immediately upon the ceſſation thereof.

Two or three ſpoonfuls of burnt alabaſter, mixed up thin with water, in a ſhort time coagulate, at the bottom of a veſſel full of water, into a hard lump, notwithſtanding the water that ſurrounded it. Artificers obſerve, that the coagulating property of burnt alabaſter will be very much impaired or loſt, if the powder be kept too long, eſpecially if in the open air, before it is made uſe of; and when it hath been once tempered with water, and ſuffered to grow hard, they cannot, by any burning or powdering of it again, make it ſerviceable for their purpoſe as before. Boyle's Works Abr. vol. i. p. 133. 313. 341.

This matter, when wrought into veſſels, &c. is ſtill of ſo looſe and ſpongy a texture, that the air has eaſy paſſage through it. Mr. Boyle gives an account, among his experiments with the air-pump, of his preparing a tube of this plaſter, cloſed at one end and open at the other, and on applying the open end to the cement, as is uſually done with the receivers, it was found utterly impoſſible to exhauſt all the air out of it; for freſh air from without preſſed in as faſt as the other, or internal air, was exhauſted, though the ſides of the tube were of a conſiderable thickneſs. A tube of iron was then put on the engine; ſo that being filled with water, the tube of plaſter of Paris was covered with it; and on uſing the pump, it was immediately ſeen, that the water paſſed through into it as eaſily as the air had done, when that was the ambient fluid. After this, trying it with Venice turpentine inſtead of water, the thing ſucceeded very well; and the tube might be perfectly exhauſted, and would remain in that ſtate ſeveral hours. After this, on pouring ſome hot oil upon the turpentine, the caſe was much altered: for the turpentine melting with this, that became a thinner fluid, and in this ſtate capable of paſſing like water into the pores of the plaſter. On taking away the tube after this, it was remarkable that the turpentine, which had pervaded and filled its pores, rendered it tranſparent, in the manner that water gives tranſparency to that ſingular ſtone called *oculus mundi*. In this manner, the weight of air, under proper management, will be capable of making ſeveral ſorts of glues penetrate plaſter of Paris; and not only this but baked earth, wood, and all other bodies porous enough to admit water on this occaſion. Phil. Tranſ. N° 122.

Plaſter of Paris, diluted with water into the conſiſtence of a ſoft or thin paſte, quickly ſets or grows firm, and at the inſtant of its ſetting, has its bulk increaſed; for Mr. Boyle has found, that a glaſs veſſel, filled with the fluid mixture, and cloſely ſtopped, burſts while the mixture ſets, and ſometimes a quantity of water iſſues through the cracks.

This expanſion of the plaſter, in paſſing from a ſoft to a firm ſtate, is one of its valuable properties; rendering it an excellent matter for filling cavities in ſundry works, where other earthy mixtures would ſhrink and leave vacuities, or entirely ſeparate from the adjoining parts.

It is probable alſo, that this expanſion of the plaſter might be made to contribute not a little to the elegance of the impreſſions which it receives from medals, &c. by properly confining the ſoft matter, that its expanſion may force it into the minuteſt traces of the figure; the expanſion of the matter doing the ſame office as the preſſure by which the wax is forced into the cavities of a ſeal.

Plafter of Paris promotes the fufion of forged iron.

This fubftance is commonly ufed for taking cafts and impreffions from figures, bufts, medals, &c. as it is adapted to the double ufe of making both cafts and moulds for forming them. See *Impreffions of* MEDALS.

PLASTER *of Paris*, in *Agriculture*, a fubftance of the calcareous kind, in combination with the vitriolic acid, which has been fometimes made ufe of as a manure. See GYPSUM and *Sulphate of* LIME.

PLASTER, in *Gunnery*, a piece of greafed leather or rag, ufed by riflemen, &c. to make the ball fit the bore of the piece.

PLASTER *Floors*, in *Rural Economy*, fuch floors as are conftituted of plafter, prepared from fuch lime as poffeffes a ftrong binding property. They are highly ufeful in cottages and farm-houfes, as affording much fecurity againft fire. In conftructing them, it is obferved, in the firft volume of Communications to the Board, that the joifts are laid in the ufual manner; after which a fort of ftrong reed, which is found in Huntingdonfhire, is nailed on, upon which the plafter is applied; but in order to fave it, there is frequently a thin coat of common lime laid on firft, to fill up the crevices and inequalities. On this the plafter is then fpread out, to the thicknefs of about two inches, being laid on with as much expedition as poffible. The plafter is fold at the kilns in the midland diftricts, at 6*d.* the bufhel: and the expence of laying it on, if burnt and prepared, is 5*d.* the fquare yard; but if to be burnt and prepared by the workmen, about as much more. The floors are faid to be excellent and cheap. Where reeds cannot be procured, laths may be made ufe of, but they come much higher. Floors of this fort are much in ufe in Nottinghamfhire, as well as in Rutlandfhire, at the earl of Winchelfea's, where the upper floors of his farm-houfes are made of it.

Thefe kinds of floors fhould be more attended to, in conftructing fmall houfes both of the cottage and other kinds, as being cheap, readily laid, and at the fame time fecure.

PLASTERING, in *Architecture*, is that operation which confifts in laying on coats of mortar, varioufly prepared, on the ceilings and walls, &c. of different buildings. This belongs to a clafs of artificers called plafterers. See PLASTER.

Plafterers' work is of two kinds: namely, ceiling, which is plaftering upon laths; and rendering, which is plaftering upon walls. Thefe are meafured feparately. The contents are eftimated either by the foot, or yard, or fquare of 100 feet. Inriched mouldings, &c. are rated by running or lineal meafure. Deductions are to be made for chimnies, doors, windows, &c. But the windows are feldom deducted, as the plaftered returns at the top and fides are allowed to compenfate for the window opening.

It were much to be wifhed that this art of plaftering could be again brought to its ancient perfection. In our beft buildings the plaftered walls and cielings crack and fly, and in a little time grow damp, or moulder to decay.

The Romans had an art of rendering their works of this kind much more firm and durable, and there is no reafon to defpair of reviving this art by proper trials.

The ancient plaftering of thefe people preferved to this time, where it has not met with violent blows or injuries from accidents, is ftill found as firm and folid, as free from cracks or crevices, and as fmooth and polifhed on the furface, as if made of marble. The bottoms and fides of the Roman aqueducts were made of this plaftering, and endured many ages without hurt, unlefs by accidents: witnefs that whereof fome yards are ftill to be found on the top of the Pont de Gard, near Nifmes, for the fupport of which that famous bridge was built to carry water to the faid town. The roofs of houfes, and the floors of rooms, at Venice are covered with a fort of plafter, made of later date, and yet ftrong enough to endure the fun and weather for feveral ages, without cracking or fpoiling, and without much injury from people's feet.

The fecret of preparing this Venetian plafter is not among us; but it would be worth while to try whether fuch a fubftance might not be made by boiling the powder of gypfum dry over the fire, for it will boil in the manner of water; and when this boiling or recalcining was over, the mixing with it refin, or pitch, or both together, with common fulphur, and the powder of fea-fhells. If thefe were all mixed together, and the water added to it hot, and the matter all kept hot upon the fire till the inftant of its being ufed, fo that it might be laid on hot, it is poffible this fecret might be hit upon.

Wax and oil of turpentine may be alfo tried as additions; thefe being the common ingredients in fuch cements as we have accounts of as the firmeft. Strong ale-wort is by fome directed to be ufed, inftead of water, to make mortar of limeftone of a more than ordinary ftrength. It is poffible, that the ufe of this tenacious liquor to the powdered ingredients of this propofed plafter, might greatly add to their folidity and firmnefs. Phil. Tranf. N° 93. See STUCCO.

Plated manufacture

PLATED MANUFACTURE, in the *Arts*. From the valuable properties possessed by silver as a metal, it is much to be regretted that it is not sufficiently plentiful, so as to be used for the fabrication of such articles as are liable to corrosion; more especially such utensils as are employed for culinary purposes. This desirable object has given rise to the desideratum of covering some of the cheaper metals with silver, and this art has always been known by the name of plating.

The art of plating with silver appears to have been first applied to articles made of brass, after they were in other respects finished. It is known by the name of French plating, and was formerly much used for brass candlesticks. After the goods were polished, and perfectly free from grease, and indeed any other extraneous matter, the part to be plated was heated to a temperature something short of changing the colour of the metal. Leaf silver was now laid upon the part, and, while hot, was rubbed on with a hardened steel burnisher, perfectly dry and clean. By this means the silver adhered firmly to the brass, which, from the action of the burnisher, assumed a fine polish. These had much the appearance in colour and lustre of those of the present day. They possessed but little permanence, owing to the thinness of the covering. This art is scarcely now practised, from the introduction of the superior plan of plating upon ingots of copper, and forming the utensils out of the sheets and wire made from the ingots. This latter is at present carried on to an immense extent in Sheffield, and also at Birmingham, but on a lesser scale.

The inventor of this method of making plated articles was not aware of its great importance. He began by making it into snuff-boxes, and other trifling articles. It afterwards was extended to the manufactory of pints and tankards, and other articles, by a Mr. Hancock, who erected a mill near Sheffield for rolling the ingots. This mill is at present employed for this purpose by the son of the above gentleman.

The plated manufacture is divided into three departments, in each of which a distinct set of workmen is employed.

Those workmen employed in making vessels, such as are required to be raised by the hammer, are called braziers, probably from braziers being first employed in it.

The next are called candlestick makers, being exclusively employed in making all the varieties of these articles.

The next and last are called pierce-workers: these were originally employed in making articles with ornamental open work, such as bread-baskets, and trays of different kinds.

This open work was formed by piercing the substance with punches of different shapes, by means of a screw-press called a fly.

This species of work is now become obsolete, since the invention of plated wire. The articles in which pierce-work had been made, are now formed by the varied intersections of wires, which give great lightness and elegance, with less waste and more expedition. The workmen employed in this department are still called pierce-workers.

Previously to describing particularly the different branches of this art, we shall give the method of preparing the plated sheets and wire of which all the different articles are made.

The ingots on which the silver is laid are not pure copper, but an alloy, consisting of copper and brass; this gives it a degree of stiffness greater than that of copper, which renders it less liable to be deformed when in use.

Fig. 12. in *Pl. Plated Manufacture*, represents a section of the furnace used for melting the alloy for the purpose of casting. The crucibles are those made at Chelsea with black-lead. The ingot-moulds are of cast-iron, consisting of two pieces, fastened together by two rings, with wedges, the interior being of the shape of a parallelepipedon, about three inches broad, $1\frac{1}{4}$ in thickness, and about eighteen or twenty long. The mouth-piece, into which the metal is poured, makes an angle with the length of the cavity; so that when the mould is placed on the ground, with the narrow side uppermost, and makes an angle with the horizon of about ten degrees, the mouth-piece points directly upwards. The inclination of the mould and the length of the mouth-piece are to give a certain head of liquid metal, which determines the impurities of less specific gravity than the metal to rise into the cavity of the mouth-piece, in order to insure the soundness of the ingot. If this were not attended to, the sheets rolled from such ingots would abound with seams and loose places. It is easy to see that a small hole in the ingot would be the source of a seam by extension, and a larger cavity would have the effect of making hollow places in the substance of the sheet, which frequently peel off with the silver after plating.

The proper heat of the metals, and the temperature of the mould when the metal is poured, are of great importance, as far as regards the soundness of the ingot. When the metal is too cold, and its liquidity of course imperfect, the impurities cannot freely ascend, which causes imperfection in its substance. The same effect may take place from the moulds being cold: this, with the great conducting power of the metal mould, rapidly robs the metal of its caloric, and lessens its liquidity. The proper heat for the moulds is something short of burning the fat with which they are greased on the interior surface. The presence of fat which contains hydrogen has a happy effect in preventing the surface being rough. Its presence is therefore essential, and hence the moulds should never be so hot as to destroy it. On the other hand, the metal should not be too hot, as in this case it remains longer in the liquid state than is proper: this has the effect of allowing the metal to assume a more complete crystalline arrangement than under ordinary circumstances. When an ingot under such circumstances is broken, the crystals are very distinct. The sheet rolled from an ingot so cast, will be found to exhibit on its surface very thin loose pieces, which peel off. This is frequently a source of great mischief to the manufacturer. After the pieces are plated

and rolled, this laſt inconvenience is frequently ſo great, as to render the whole ſheet uſeleſs, except to work over again.

It will be remembered, from what we obſerved reſpecting the temperature of the ingot moulds, that the proper heat for the metal can only be acquired by practice. Men of ſome talent and obſervation ſhould have the management of caſting and plating. It is notorious, however, throughout the trade, that the men employed in this eſſential department are generally taken from the claſs of common labourers.

The beſt teſt for the proper degree of heat of the metal is its colour, and the appearance of liquidity. When it firſt fuſes it appears ſtiff, and of the colour of the red cokes of the furnace: with a greater heat it becomes more liquid, and aſſumes a blueiſh colour. This latter is the proper ſtate for pouring it into the mould. If the heat be greater, the zinc of the braſs, and perhaps the copper itſelf, begins to burn. This ariſes from the metal's aſſuming the form of vapour, which combines with the oxygen of the atmoſphere. When the metal has become ſolid in the mould, the wedges which keep the two halves of the mould together are ſlackened, to prevent the ingot from breaking, by its contraction, during cooling. When it is taken from the mould its ſurface ought to be ſmooth and metallic. Its fracture ſhould exhibit a rough uniform cryſtallization, in which the cryſtals preſent ſmall ſurfaces. If the cryſtals appear diſtinct, with large faces, the metal will be ſhelly when rolled.

For the ordinary kind of work theſe ingots are generally cut in two in the middle, being more convenient for plating than longer pieces.

The next proceſs is to dreſs the face of the ingot for the purpoſe of receiving the ſilver, on one or both ſides, as it may be intended to be ſingle or double plated. This is effected by filing, which is continued till the ſurface becomes entirely free from the leaſt blemiſh. This is ſo important, that the naked eye ſhould not be depended upon. A very ſmall hole in the ingot would become a ſurface on rolling, and the ſilver would come off in that part. The ſurface of the copper ſhould, therefore, be minutely examined by a magnifier before the ſilver is laid on. The thickneſs of the ſilver to be laid on the copper will be beſt known, when it is underſtood, that the ſilver, in ſingle plated metal, or that plated on one ſide only, is from 8 to 10 pennyweights to the pound troy of copper; and, of courſe, double that quantity when plated on both ſides. If the ingot of copper be $1\frac{1}{4}$ thick, the ſilver plate to be laid upon it, at eight pennyweights to the pound, will be $\frac{1}{72}$ of an inch, and a ſquare inch of it will weigh about 90 grains. When the plate of ſilver is cut to a little leſs than the ſize of the copper ſurface, made flat, and ſcraped perfectly clean, the copper ſurface being equally clean, they are laid together, and the ſilver plate is tied down with wire. A little of a ſaturated ſolution of borax is now inſinuated under the edge of the ſilver plate on every ſide: this fuſes at a low red heat, and prevents the oxygen of the atmoſphere from affecting the ſurface of the copper, which would prevent the adherence of the ſilver. In this ſtate the ingot is brought to the plating furnace.

In *fig*. 12. B is an iron door, with a ſmall hole to look through. This furnace has a grate on a level with the bottom of the door. The fuel conſiſts of cokes. The ingot is laid upon the bare cokes, and the door ſhut. When it has acquired nearly a proper degree of heat, the plater applies to the hole in the door to obſerve the proper point, when the proceſs is finiſhed. When the ſilver and copper are uniting, the ſurface of the former begins to be rivetted, and this is the ſign to remove the ingot from the fire as quick as poſſible. If it were allowed to ſtop longer, the ſilver would become alloyed with the copper, and completely ſpoiled.

In this proceſs, the ſilver is, in fact, ſoldered to the copper, although no ſolder is expreſsly employed. It is well known to chemiſts, that an alloy of ſilver and copper, as well as many other alloys, is more fuſible than either of the ſimple metals. From what takes place in the above proceſs, it will be eaſily inferred, that a portion of ſilver and copper unite at contiguous ſurfaces, which fuſing before the ſilver or the copper, unite the ſilver with the copper. The ingot, being now plated, is made perfectly clean, and is ready to be rolled. The firſt rollers employed for plated metal are of caſt-iron, ſimilar in ſize and conſtruction to thoſe employed for ſheet iron and ſheet copper. (See Rolling Mill.) The metal is rolled cold, and annealed from time to time. When it has gone through the rollers a certain number of times, it acquires a certain degree of hardneſs, ſo that the rollers have not much effect upon it; and if the rolling were continued, the metal would crack. To remedy this evil, the metal is taken to a reverberatory furnace. It is laid upon a hearth of brick or fire-ſtone, and the flame of coal made to paſs over it. The heat, however, is not intenſe, ſince the metal is required to be ſlowly heated to a dull red. It may now be cooled in the quickeſt way poſſible to ſave time, as quenching in water does not affect it, as is the caſe with ſteel. It now paſſes through the rollers, as before, till it becomes hard, and then annealed and rolled again, till it is reduced ſomething ſhort of the ſize required. This being done, it is again annealed and paſſed through a pair of rollers faced with caſt ſteel, and finely poliſhed. This gives the ſurface great ſmoothneſs and truth. It is now annealed for the laſt time: after this, the ſheets are immerſed in hot dilute ſulphuric acid, then ſcowered with fine Calais ſand, which fits them for the workmen to ſhape into different articles.

Having deſcribed the method of preparing the ſheet plated metal, we ſhall next give an account of the method employed for manufacturing plated wire. This is generally a diſtinct buſineſs, being unconnected with the buſineſs of making the plated goods.

The pieces of metal to be plated for the purpoſe of making wire, are forged out of bar copper unalloyed. Theſe pieces are of a cylindrical ſhape, and about 18 or 20 inches long, and about $1\frac{1}{4}$ inch in diameter. The true cylindrical ſhape is given to the copper by wire-drawing: it is then made perfectly clean and metallic by ſcraping. The ſilver to be laid upon it is much thinner in proportion to the copper than was ſtated in the ſheet metal. The ſilver is firſt formed into a tube, one edge projecting a little over the other. A copper cylinder, a little leſs in diameter than the tube, and ſo much longer as to admit one end of it being faſtened into a hole, is now heated red-hot, and faſtened by one end in the hole. The tube is now ſlipped upon it, with the ſeam upwards. A flat ſteel burniſher, with rounded poliſhed edges, and a handle at each end, is now rubbed briſkly backward and forward upon the overlapped edges of ſilver, at the ſame time uſing conſiderable preſſure. By this means the two ſurfaces are completely welded together, ſo that it would be difficult to find where the union had taken place.

The cylinder of copper intended to be plated, is now made perfectly clean, the inſide of the ſilver tube being the ſame. It is now put upon the cylinder, which is about

two inches longer than the tube; a ſmall groove is made round the cylinder coinciding with the ends of the ſilver tube. Into this groove the ends of the tube are cloſely worked, ſo as to render the ſpace between the tube and the cylinder perfectly air-tight. The neceſſity of this will be obvious, ſince the whole is required to be heated red-hot, which would cauſe the oxydation of the copper, and prevent the ſilver from adhering to it. When the cylinder and tube are together heated ſlightly red-hot, the ſame burniſher that was uſed to unite the tube is now rubbed briſkly over the tube in a longitudinal direction. This unites the ſilver firmly to the copper, and makes it fit for drawing into wire of various forms and ſizes. The machinery employed for drawing this wire is preciſely ſimilar to that employed for braſs and copper wire. The great variety of figure and form given to it depends upon the plate through which it is drawn. Some are flat, others half round, ſome fluted, or with mouldings. It is chiefly uſed for making bread-baſkets, toaſt-racks, ſnuffers, and many other articles, affording much neatneſs and elegance, with little manual labour. The wire after drawing, like ſheets after rolling, is annealed, and afterwards cleaned with hot dilute ſulphuric acid.

We ſhall firſt deſcribe the manufacture of ſheet metal into various articles. It may be eaſily conceived, that the nature of this metal is ſo ſimilar to copper, that the working of it with the hammer into various forms will be very ſimilar to that uſed by copperſmiths, with the difference of more exact and complete tools, and greater care on account of the value of the metal. Formerly all the different ſhaped veſſels were made with the hammer, which made the price of labour very great. Now, all veſſels of ſimple form, and not of large ſize, are formed in dies by means of the ſtamping hammer. This operation is now ſo general, that ſome manufacturers employ as many as ſix or eight of theſe engines.

Figs. 1 and 2 are two views of the ſtamp. A is a large ſtone, the larger the better; *b*, the anvil on which the die, *e*, is ſecured by four ſcrews. See ground plan.

In *fig.* 1. *a*, *a*, are two upright ſquare pillars, with the angles oppoſed to each other, which work in angular receſſes in the hammer *d*. This admits the hammer to ſlide freely and truly from top to bottom, by pulling at the rope *f*, ch paſſes over the pulley *c*. This hammer is let fall from different heights, according to the effect to be produced.

All veſſels may be raiſed by the ſtamp, with the exception of ſuch as are immoderately large, or thoſe of inordinate depth, compared with the diameter. Veſſels which are of leſs diameter at the top and bottom than in the middle, muſt either be ſtamped on two pieces, or raiſed with the hammer by hand.

The dies are, or ought to be, made of caſt ſteel, but it ſhould be as hard as to weld to iron, ſo that the iron ſhould not be much below the ſurface of the die. This precaution is neceſſary only when the die requires to be hardened. . In other reſpects the whole may be caſt ſteel. Thoſe unhardened ſhould be of harder caſt ſteel. No other ſteel can anſwer, as it would be liable to abound with flaws, and would not be uniformly hard.

When the die is placed upon the anvil, and the metal cut into pieces of proper ſize, the next thing is to ſurround the top of the die with a paſte made with oil and clay, an inch or two above the ſurface. This cavity is now filled with melted lead. The under ſide of the ſtamping hammer has a flat face of iron fitted into it, about the breadth and length of the die: this is called the *lickerup*. When the lead becomes ſolid, the hammer is raiſed to a certain height and let fall upon it. The underſide of the *lickerup*, from being cut on the ſurface into teeth in ſhape like thoſe of a raſp, firmly adheres to the lead, which afterwards riſes with the hammer. The metal is now placed over the die, and the hammer with its lead made to fall upon it, till the impreſſion on the metal is complete. If the veſſel to be ſtamped be of any conſiderable depth, two or three dies are often uſed, one bigger than another, the laſt being of the proper ſize and ſhape. It ſometimes happens, that when the veſſel has a long conical neck, they are obliged to have recourſe to an auxiliary operation called drafting. Theſe in the plate are called emboſſing punches.

In *fig.* 11. the punches are made of caſt ſteel, and the cavities turned out in a lathe. The pieces *a*, *b*, are of lead. This operation is performed by a ſeries of theſe punches of different ſizes, beginning with the largeſt firſt, and gradually going on to the ſmalleſt. By this means a hollow cone may be raiſed out of a flat plate, three or four inches in length, and not more than an inch in diameter at the wideſt part. Theſe punches are alſo employed for ſmall articles of too great delicacy for the ſtamp.

It frequently happens, that one part of an article is made by the ſtamp, and the reſt by the hammer. Sometimes they are rudely formed by the hammer and finiſhed by the die.

Cylindrical and conical veſſels are moſtly formed by bending and ſoldering. The bending is performed on blocks of wood with wooden hammers, to avoid injuring the plated ſurface. We ſhall here recommend a method of turning rings, or any thing in a cylindrical or conical ſhape. It is already uſed to great advantage by tin-plate workers. This is done by a machine conſiſting of three rollers, a ſection of which is ſhewn in *figs.* 5 and 6. A, B, C, are the three rollers, and *a b c d* the piece of metal paſſed through them to receive the cylindrical or conical ſhape.

The upper roller, A, can be raiſed or lowered at pleaſure, which has the effect of determining the diameter of the cylinder. When one end of the upper roller is higher than the other, it gives the conical ſhape. In order to ſolder the cylinder or cone, the two edges are made very true, and are kept in contact by binding with ſmall iron wire. The part where the ſolder is intended to be run muſt be made perfectly clean by ſcraping. The ſolder employed is that called ſilver ſolder. It is an alloy of braſs and ſilver, or rather an alloy of ſilver, zinc, and copper. The alloy of copper and ſilver is more fuſible than either of theſe metals, and may be employed as a ſolder for ſilver, copper, or plated metal, when the plated metal has no zinc in its compoſition. It is, however, neceſſary to employ an alloy of braſs and ſilver as a ſolder for plated metal. The braſs ſhould be the leaſt poſſible, being no more than what is neceſſary to give the requiſite fuſibility to the ſolder, ſince too much braſs would not only injure the colour, but its malleability is impaired, and the ſeam would break when it came to be hammered.

The ſolder is firſt caſt into an ingot, and then rolled thin enough to cut with ſhears into ſmall ſhreds. Beſides the ſolder they alſo employ borax, and a ſubſtance which floats on the top of melted glaſs, and is taken off as refuſe. It is called *ſandiver*, and probably conſiſts of ſulphat of potaſh and flint. The borax is firſt calcined, which conſiſts in driving off the water of cryſtallization. The white powder is then mixed with a little water, a ſmall quantity of the powdered *ſandiver* being at the ſame time added. After the ſeam to be ſoldered has been ſmeared with this pulpy maſs, and the bits of ſolder laid on, the whole is expoſed to the heat of a lamp with a blowpipe; or if the ſubſtance be large, to a charcoal fire, urged with bellows. The borax firſt

fuses, and defends the parts to be united from the action of the air. The heat is then increased rapidly till the solder melts. The use of the sandiver is to prevent the iron wire from being soldered to the other metal. It appears that the salt in this substance is decomposed by the iron, by which the surface of the lathe becomes oxydated, and prevented from uniting with the silver or the copper. The sandiver has no action upon the other metals, and therefore does not prevent their union. When the united part is made clean, and hammered with polished tools, the seam cannot be seen on the silvered side. If a yellow line appear, the solder contains too much brass.

Vessels intended to have other forms are generally soldered up in a conical or a cylindrical form, according as the width at the top and bottom of the vessel varies. The metal is so malleable, even in the soldered part, that a skilful workman can give almost any form to a vessel with the hammer.

Mouldings are sometimes formed upon the edges of vessels, which serve to give much strength and stiffness, as well as being ornamental. This operation is performed by an instrument called a swage, see *figs*. 3 and 4. The part A lifts up by a joint, and the metal to be swaged is placed between the dies, as shewn in the figures: the part *b* is held in a vice, while the other rests upon it. By striking on the part A, at the same time shifting the metal forward, the bead is formed. In *fig*. 3, the part *a* is a guide to regulate the distance of the bead from the edge. The same effect is produced in a neater and more expeditious manner by the rollers, *figs*. 8, 9. *Fig*. 10. is a section, shewing the form of the bead. The two wheels *a*, *a*, (*fig*. 8.) are placed upon an axis, which have pinions for the purpose, the lower one giving motion to the upper one. The groove in the upper wheel corresponds with the bead in the lower one, and the metal passed between assumes the same figure. This machine, a little varied, may be used as shears to cut the metal into pieces of uniform breadth. A part of the upper wheel *a*, for this purpose must be a little larger, and the edges square and sharp. The lower wheel being put on first, the other must be put on to the other axis, till the face of the enlarged part comes up to that of the other wheel, and in this situation secured by nuts. It will be evident, that if a piece of metal be now placed between them, that the metal will be cut by the projecting part of the upper wheel, in a similar manner to that employed for slitting iron.

The beading and moulding, however, is not at present much used. When prominent parts like these are merely plated metal, they, from being more exposed, soon become bare, and the copper surface is presented.

The greatest improvement ever made in this branch of manufacture, is the introduction of silver edges, beads, and mouldings. Without this means of defending the prominent parts which become so soon bare in the old method, the trade must long since have gone into disgrace, and ultimately to decay. The silver intended to form the prominent and ornamental parts is rolled extremely thin, a superficial inch sometimes not weighing more than 10 or 12 grains.

This is too delicate to have the ornamental form given to it by the swage above described. The two opposite dies being steel, if not very accurately made, would tear silver so delicate as that used for ornaments. It is necessary, therefore, that the sunk part of the die should be steel, and the opposite side lead, as was observed in the stamping, and this is the method generally employed to form these silver ornaments. It seems wonderful, that manufacturers have not thought of doing this by small rollers. It would only require to have the part in which the die is sunk a wire ring of cast steel, the concave part being a little conical, and made to exactly correspond with a convex cone on one of a pair of rollers, so that by a little force it may be as firm as a solid roller. A ring of lead, or even a straight piece, might act opposite to the die. A much greater variety of dies might be made in this way, than by making dies flat. The dies would cost less, and be better executed. The silver would also run less risk of tearing, than by the stamp or the swage.

When these silver mouldings are formed, and the refuse metal poured off, they are laid upon a level plate, with the hollow side upwards. Small bits of resin are put into the hollow parts, and soft solder melted in with a soldering iron, the point of the same being applied into the groove to keep it in a state of fusion. This is continued till the cavity is quite full. To prevent the solder from accidentally adhering to the convex part, it is previously covered with a paint-like compound of size and whitening. The same expedient is resorted to in all cases where soft solder is employed, or when it is applied to great heat. The soft solder is formed of equal parts of lead and tin. The former metal has so great an affinity for lead, as to require the greatest care to keep these metals separate when one of them is in a state of fusion.

The silver shells, thus filled with soft solder, will now admit of being bent into almost any form. After they are fitted accurately to the place they are to occupy, the part being first made clean and partially tinned, they only require to be secured by temporary fastenings, till the parts can be exposed to a degree of heat capable of melting the solder. This unites the ornament, without leaving any appearance of solder on the outside.

In forming substances which have a massive appearance, such as the feet of tea urns, the handles of vessels, and plated table spoons, no other metal is employed but the sheet. The mass is formed of two shells, which, when put together, form an apparent solid. Each of the concave parts is first filled with soft solder, they are then fitted accurately together, and heat applied till the mass fuses, so that the apparently massive article consists of a shell of plated metal filled with soft solder. Bulky ornaments, in the form of shells and flowers, are frequently put on in this way; some in silver. These have a similar massive appearance to, and strongly imitate, real plate.

All goods formed by hand with the hammer, require great labour in finishing. After hammering the vessel into the proper shape, the marks of the hammer appear like so many flat places. These are removed from the outside of the vessel to the inside, when the inside is concealed, as in tea urns. This is effected by covering either the anvil or the hammer with a piece of the stuff called everlasting. The roughness is transferred to that surface in contact with the everlasting. In hammering plated metal from time to time, it requires to be annealed by heating it red-hot: this discolours both the silver and the copper. These are cleaned by boiling in dilute sulphuric acid, and scowering with Calais sand. The sulphuric acid to the water is in very small proportion. If the silver begins to appear black by boiling, the acid is too much, and must be watered. When the vessels are finished in every respect by the maker, and the surface free from oxyd, it frequently happens that bits of rosin, used with soft solder, adhere to it. This is removed by boiling in a weak solution of pearl ashes. The same is also used for cleaning the surface of tinned copper.

The vessels are now ready for burnishing, a process which we shall soon describe.

Our inftructions hitherto have particularly applied to braziers' work; we fhall next defcribe the candleftick-making.

In this branch of the bufinefs there is great variety. In the commencement of this trade the object was chiefly to imitate thofe made of filver, and it began with the prevailing tafte of imitating the different orders of architecture. The numerous points and prominences thus introduced, were ill fitted for plated metal, as in a very little time their filver difappeared, which gave them the moft fhabby appearance poffible. This obliged the manufacturers to make them more plain and fimple, and it was not till the difcovery of the filver edges, that candlefticks of plated metal began to gain refpect in the world of luxury and fafhion. The ftems of candlefticks have been made fquare; fome with fharp, others with rounded corners; others oval, but the greateft number with round ftems, which appear to be the moft confiftent and the moft permanent. Of thefe, the patent telefcope candleftick has had the greateft run. This confifts in the cylindrical part lengthening and fhortening at pleafure, by one tube fliding into the other. In this cafe the tubes are drawn by machinery, fimilar to that ufed for drawing the tubes of telefcopes. The feet of candlefticks, or the bafe, are generally made in a die by the ftamp. The neck, which is fometimes fmall in one part, is alfo ftamped. The difh part of the nozzle or focket is made in a die, and the tube part in the fame way as the cylindrical pillar. Thefe, for the fake of neatnefs and expedition, are generally drawn in the wire drawing machine, whether for fliding or not. Some of thefe tubes are fluted. The prominent moulding and beads are generally of filver. The different parts are foldered together, fome parts with hard and others with foft folder. The branches of candlefticks are formed in two halves, like the tea urn feet, &c. In forming fuch articles as are made of wire, fuch as bread bafkets, toaft racks, and cafters, the wire is bent into the given form with a wooden block and a mallet. When pieces require to be foldered together, the joinings muft be accurately fitted, in order to prevent the copper from appearing. In thefe cafes hard folder is employed. This branch of plated manufacture admits of extenfive application. Wires are capable of great variety of pofitions. The work lately publifhed by fir James Hall, feems to prove that Gothic architecture has originated in the fanciful forms of bended twigs. The perufal of this work could not fail to give important hints to an ingenious manufacturer of plated wire work.

Plated goods, particularly tea urns, and globular veffels for the fame purpofe, frequently require to be engraved; but it is obvious that, from the extreme thinnefs of the plate, the graver would lay bare the copper; and if the plate was fo thick all over as to admit of engraving, the articles would be very expenfive. Both thefe evils are obviated, by working an extra plate of filver on to the part to be engraved. This is done while the plate, of which the veffel is made, is in its flat form. The part where the engraving will fall is firft fcraped clean, and a plate of filver, of fimilar thicknefs to that employed for filver edges, is cut to the fame fize, and alfo fcraped clean. The plated fheet is then laid upon a hot anvil, and the plate of filver laid upon the place prepared. It is firft rubbed flowly, but with great preffure, with a polifhed hammer previoufly heated, but not fo as to affect the polifh. The plate will begin to adhere, and it may then be flightly hammered; ultimately it will adhere all over, and may now be hammered on a polifhed ftake, till the whole furface becomes plane, and the piece of filver cannot be diftinguifhed from the reft. This procefs is on the fame principle as the plating of wire, and is fimilar to welding two pieces of iron together. It appears practicable that the furfaces of any malleable metals, when clean and heated to acquire a certain degree of foftnefs, are capable of uniting. Moft people are familiar with the union of two pieces of lead by preffure, even at the common temperature.

When the different plated goods come out of the hands of the workmen, the metal, although clean, is of a dull white colour, poffeffing no polifh whatever.

This laft finifh is called burnifhing, and is generally performed by females in a diftinct fet of apartments. The burnifhing tools are generally made of blood-ftone, and fome of hardened fteel finely polifhed. The latter are to burnifh the minute parts which cannot be touched by the blood-ftone, which are employed chiefly for the greater and uninterrupted parts.

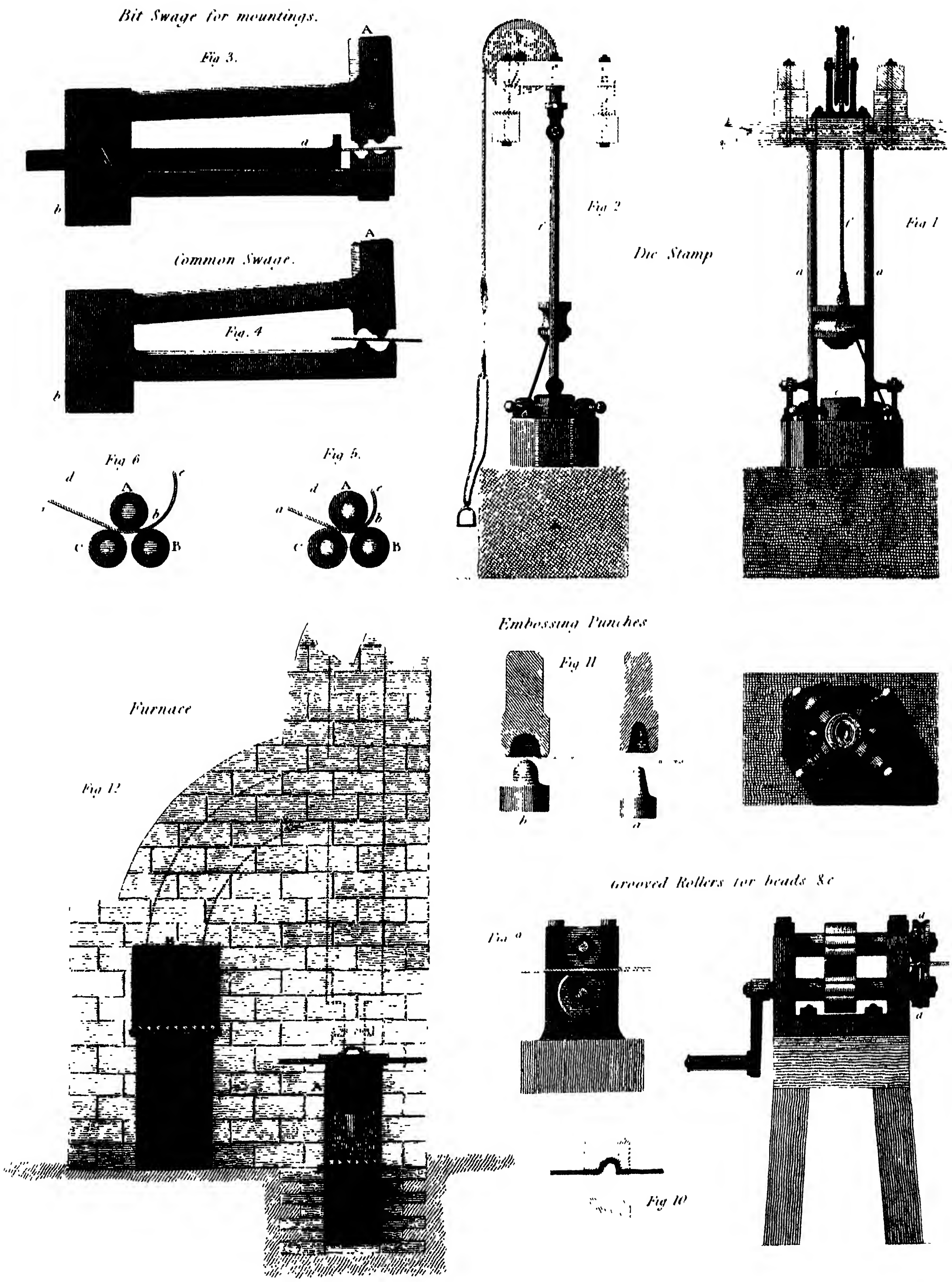
The bits of blood-ftone are let into little cafes, made of fheet iron, and then finely polifhed.

The burnifhers, if ufed dry, would adhere to the filver in fome places, and would fcratch inftead of giving the fine polifh intended. This is obviated by frequently dipping the burnifhing tool into a folution of white foap. After being burnifhed they are raifed, and laftly wiped with clean fheep's leather.

It is a circumftance much to be regretted, that filver, although it is fufceptible of fo fine a polifh, does not keep its luftre. This is occafioned by the fulphur which comes from fulphurated hydrogen, a gas always exifting in the atmofphere. The thinneft coating of any fubftance will prevent this change. If the furface of filver were coated with a folution of gum arabic or ifinglafs, the defence will not be perceived, and the filver will never change colour.

We fhall conclude this article with a few remarks upon the prefent mode of plating the ingots intended for fheets. It will be evident, that fince the heat in plating muft be equal to forming a portion of an alloy of filver and copper, which by its early fufion unites the two furfaces together, the filver will not be uniform in its quality, and by wearing will prefent an alloy having more than its proper quantity of copper; and will, in confequence, exhibit a bafe colour. It will be remembered, that the method ufed for plating the wire ingots does not admit of this inconvenience. The filver will keep its colour to the laft. We fhall no doubt hear, at fome period when the plated manufacturers employ men of talent as platers, that the ingots for rolling will be plated by the method employed for the wire.

PLATED MANUFACTURE.



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Plotting

PLOTTING, among *Surveyors*, the art of defcribing or laying down on paper, &c. the feveral angles and lines of a tract of ground furveyed by a theodolite, or the like inftrument, and a chain.

In furveying with the plain-table, the plotting is needlefs; the feveral angles and diftances being laid down on the fpot as faft as they are taken.

But in working with the theodolite, femicircle, or circumferentor, the angles are taken in degrees; and the diftances in chains and links. So that there remains a fubfequent operation, to reduce thofe numbers into lines; and fo to form a draught, plan, or map. The operation is called *plotting*.

Plotting, then, is performed by means of two inftruments, the protractor and plotting-fcale. By the firft, the feveral angles obferved in the field with a theodolite, or the like, and entered down in degrees in the field-book, are protracted on paper in their juft quantity.

By the latter, the feveral diftances meafured with the chain, and entered down, in like manner, in the field-book, are laid down in their juft proportion.

Under the articles PROTRACTOR and PLOTTING-*fcale*, is found, feverally, the ufe of thofe refpective inftruments in the laying down of angles and diftances; we fhall here give their ufe conjointly, in the plotting of a field, furveyed either with the circumferentor, or theodolite.

PLOTTING, *Method of, from the circumferentor.* Suppofe an inclofure, *e. gr.* A B C D E F G H K (*Plate* VI. *Surveying*, *fig.* 10.) to have been furveyed: and the feveral angles, as taken by a circumferentor in going round the field, and the diftances, as meafured by a chain, to be found entered in the field-book, as in the following table.

	Deg.	Min.	Cha.	Link.
A	191	00	10	75
B	297	00	6	83
C	216	30	7	82
D	325	00	6	96
E	12	24	9	71
F	324	30	7	54
G	98	30	7	54
H	71	00	7	78
K	161	30	8	22

1. On a paper of the proper dimenfions, as L M N O (*Plate* VI. *Surveying*, *fig.* 11.) draw a number of parallel and equidiftant lines, reprefenting meridians, expreffed in dotted lines. Their ufe is, to direct the pofition of the protractor; the diameter of which muft always be laid either upon one of them, or parallel thereto; the femicircular limb downwards for angles greater than 180, and upwards for thofe lefs than 180°.

The paper being thus prepared, affume a point on fome meridian, as A, whereon lay the centre of the protractor, and the diameter along the line. Confult the field-book for the firft angle, *i. e.* for the degree cut by the needle at A, which the table gives you 191°.

Now fince 191° is more than a femicircle or 180°, the femicircle of the protractor is to be laid downwards; where, keeping it to the point with the protracting pin, make a mark againft 191°; through which mark, from A, draw an indefinite line A *b*.

The firft angle thus protracted, again confult the book for the length of the firft line A B. This you find ten chains 75 links. From a convenient fcale therefore, on the plotting-fcale, take the extent of 10 chains 75 links between the compaffes; and fetting one point in A, mark where the other falls in the line A *b*, which fuppofe in B: draw, therefore, the full line A B for the firft fide of the inclofure.

Proceed then to the fecond angle; and laying the centre of the protractor on the point B, with the diameter as before directed, make a mark, as *c*, againft 297°, the degrees cut at B; and draw the indefinite line B *c*. On this line, from the plotting-fcale, as before, fet off the length of your fecond line, *viz.* 6 chains 83 links; which extending from B to the point C, draw the line B C for the fecond fide.

Proceed now to the third angle or ftation: lay then the centre of the protractor, as before, on the point C; make a mark, as *d*, againft the number of degrees, cut at C, *viz.* 216° 30′: draw the indefinite line C *d*, and thereon fet off the third diftance, *viz.* 7 chains 82 links; which terminating, *e. gr.* at D, draw the full line C D for the third fide.

Proceed now to the fourth angle D: and, laying the centre of the protractor over the point D, againft 325°, the degree cut by the needle, make a mark *e*; draw the occult line D *e*, and thereon fet off the diftance 6 chains 96 links; which terminating E, draw D E for the fourth line: and proceed to the fifth angle, *viz.* E.

Here the degrees, cut by the needle, being 12° 24′ (which is lefs than a femicircle), the centre of the protractor muft be laid on the point E, and the diameter on the meridian, with the femicircular limb turned upwards. In this fituation make a mark, as before, againft the number of degrees, *viz.* 12° 24′, cut by the needle at E; draw the line E *f*, on which fet off the fifth diftance, *viz.* 9 chains 71 links; which extending from E to F, draw the line E F for the fifth fide of the inclofure.

After the fame manner proceed orderly to the angles F, G, H, and K; then placing the protractor, making marks againft the refpective degrees, drawing indefinite lines, and fetting off the refpective diftances, as above, you will have the plot of the whole inclofure, A B C, &c. Such is the general method of plotting from this inftrument; but it muft be obferved, that in this procefs, the ftationary lines, *i. e.* the lines in which the circumferentor is placed to take the angles, and in which the chain is run to meafure the diftances, are, properly, the lines here plotted. When, therefore, in furveying, the ftationary lines are at any diftance from the fence or boundaries of the field, &c. off-fets are taken, *i. e.* the diftance of the fence from the ftationary line is meafured at each ftation; and even at intermediate places, if there prove any confiderable bends in the fence.

In plotting, therefore, the ftationary lines being laid down, as above, the off-fets muft be laid down from them; *i. e.* perpendiculars of the proper lengths muft be let fall at the proper places from the ftationary lines. The extremes of which perpendiculars, being connected by lines, give the plot defired.

If, inftead of going round the field, the angles and diftances have been all taken from one ftation, the procefs of plotting is obvious, from the example above; all here required, being to protract, after the manner already defcribed, the feveral angles and diftances, taken from the fame ftationary point in the field; from the fame point or centre on the paper. The extremities of the lines thus determined, being then connected by lines, will give the plot required.

If the field has been furveyed from two ftations, the fta-

tionary lines are to be firſt plotted, as above; then the angles and diſtances taken from each to be laid down from each reſpectively.

PLOTTING, *Method of, where the angles are taken by the theodolite*, i. e. *by back-ſight and fore-ſight* (as it is called) is ſomewhat different. To prepare the angles for plotting, the quantity of each muſt firſt be found, by ſubtracting the degrees of the fore-ſight and back-ſight from each other: the remainder is then the angle to be protracted. The uſe of parallel lines is here excluded; and inſtead of laying the protractor conſtantly on, or parallel to meridians, its direction is varied at every angle. The practice is thus:

Suppoſe the former incloſure to have been ſurveyed with the theodolite, after the manner of back-ſight and fore-ſight; and ſuppoſe the quantity of each angle to be found by ſubtraction.

An indefinite line is drawn at random, as A K, (*fig.* 11.) and on this the meaſured diſtance, *e. gr.* 8 chains 22 links, is ſet off, as in the former example: if now the quantity of the angle A have been found 140°, the diameter of the protractor is to be laid on the line A K, with the centre over A; and againſt the number of degrees, *viz.* 140, a mark made, an indeterminate line drawn through it, and the diſtance of the line A B laid down from the ſcale upon it.

Thus we gain the point B; upon which laying the centre of the protractor, the diameter along the line A B, the angle B is protracted, by making a mark againſt its number of degrees, drawing an occult line, and ſetting off the diſtance B C, as before.

Then proceed to C, laying the diameter of the protractor on B C, the centre on C protracts the angle C, and draw the line C D: thus, proceeding orderly to all the angles and ſides, you will have the plot of the whole incloſure A B C, &c. as before.

PLOTTING-*Scale*, a mathematical inſtrument uſually of box-wood, ſometimes of braſs, ivory, or ſilver, and either a foot, or half a foot long, and about an inch and a half broad.

It is denominated from its uſe in plotting of grounds, &c.

On one ſide of the inſtrument (repreſented *Plate* VI. *Surveying*, *fig.* 12.) are ſeven ſeveral ſcales or lines, divided into equal parts. The firſt diviſion of the firſt ſcale is ſubdivided into ten equal parts, to which is prefixed the number 10, ſignifying that ten of thoſe ſubdiviſions make an inch; or that the diviſions of that ſcale are decimals of inches.

The firſt diviſion of the ſecond ſcale is likewiſe ſubdivided into 10, to which is prefixed the number 16, denoting that ſixteen of thoſe ſubdiviſions make an inch. The firſt diviſion of the third ſcale is ſubdivided in like manner into 10, to which is prefixed the number 20. To that of the fourth ſcale is prefixed the number 24; to that of the fifth, 30; that of the ſixth, 40; and that of the ſeventh, 48; denoting the number of ſubdiviſions equal to an inch, in each, reſpectively.

The two laſt ſcales are broken off before the end, to give room for two lines of chords, marked by the letters C C.

On the back-ſide of the inſtrument is a diagonal ſcale, the firſt of whoſe diviſions, which is an inch long, if the ſcale be a foot, and half an inch, if half a foot, is ſubdivided, diagonally, into 100 equal parts; and at the other end of the ſcale is another diagonal ſubdiviſion, of half the length of the former, into the ſame number of parts, *viz.* 100

Next the ſcales, is a line divided into hundredth parts of a foot, numbered 10, 20, 30, &c. and a line of inches ſubdivided into tenths, marked 1, 2, 3, &c.

PLOTTING-*Scale, Uſe of the.* 1. *Any diſtance being meaſured by the chain, to lay it down on the paper.*—Suppoſe the diſtance to be 6 chains 50 links. Draw an indefinite line; ſet one foot of the compaſſes at figure 6 on the ſcale, *e. gr.* the ſcale of 20 in an inch, and extend the other to five of the ſubdiviſions, for the 50 links: this diſtance being transferred to the line, will exhibit the 6 chains 50 links, required.

If it be deſired to have 6 chains 50 links, take up more or leſs ſpace, take them off from a greater or leſſer ſcale, *i. e.* from a ſcale that has more or fewer diviſions in an inch.

To find the chains and links contained in a right line, as that juſt drawn, according to any ſcale, e. gr. that of 20 in an inch. Take the length of the line in the compaſſes, and applying it to the given ſcale, you will find it extend from the number 6 of the great diviſions to five of the ſmall ones; hence the given line contains 6 chains·50 links.

PLOTTING-*Table*, in *Surveying*, is uſed for a plain table, as improved by Mr. Beighton, who has obviated a good many inconveniences attending the uſe of the common plain table. See Phil. Tranſ. N° 461. ſect. 1.

Plumbago

PLUMBAGO, a name evidently derived from *plumbum*, lead, but whether it alludes to any colouring quality in the plant, or to the hue of its foliage, critics are not agreed. The latter feems confiftent with *P. europæa*, or Common Leadwort, whofe leaves are of a very peculiar greyifh-green. The *Polygonum Perficaria*, with dark fpots on its leaves, has fometimes borne this name, for a fimilar reafon.—Linn. Gen. 86. Schreb. 114. Willd. Sp. Pl. v. 1. 837. Mart. Mill. Dict. v. 3. Ait. Hort. Kew. v. 1. 323. Brown Prodr. Nov. Holl. v. 1. 425. Sm. Prodr. Fl. Græc. Sibth. v. 1. 131. Juff. 92. Tourn. t. 58. Lamarck Illuftr. t. 105. Gærtn. t. 50.—Clafs and order, *Pentandria Monogynia*. Nat. Ord. undetermined by Linnæus. *Plumbagines*, Juff.

Gen. Ch. *Cal.* Perianth inferior, of one leaf, ovate-oblong, tubular, with five plaits or angles, and five teeth, rough, permanent. *Cor.* of one petal, funnel-fhaped; tube cylindrical, contracted upwards, longer than the calyx; limb in five ovate, rather fpreading, fegments. *Stam.* Filaments five, awl-fhaped, unconnected with the corolla, enclofed within its tube; anthers fmall, oblong, verfatile. *Pift.* Germen fuperior, ovate, very fmall; ftyle fimple, the length of the tube; ftigmas five, flender, fimple. *Peric.* Capfule ovate, thin, of one cell and five incomplete valves. *Seed* folitary, ovate.

Obf. We find no traces of the nectary, or valves fupporting the ftamens, defcribed by Linnæus.

Eff. Ch. Corolla funnel-fhaped. Stamens inferted into the receptacle. Stigmas five. Capfule membranous, of one cell. Seed folitary.

1. P. *europæa*. Common Lead-wort. Linn. Sp. Pl. 215. Sm. Fl. Græc. Sibth. t. 191, unpubl. (P. Plinii; Ger. Em. 1254. Tripolium Diofcoridis; Column. Ecphr.

160. t. 161.)—Leaves clasping the stem, lanceolate-oblong, rough. Stem straight, erect.—Native of the south of Europe. Perennial and hardy in our gardens, but not in general cultivation. The *stem* is herbaceous, three feet high, upright, leafy, furrowed, with many straight upright flowering branches, each terminating in a simple dense *spike*, of small pale-purple *flowers* with a bristly *calyx*. The *leaves* are alternate, numerous, recurved, oblong-lanceolate, obtuse, bluntly toothed, dull green, rough but not hairy; their base tapering, then dilated round the stem or branch.

2. P. *lapathifolia*. Dock-leaved Lead-wort. Willd. n. 2. (P. orientalis, lapathi folio, flore minore albido; Tourn. Cor. 7.)—"Leaves clasping the stem, lanceolate, smooth. Stem divaricated."—Native of Iberia. *Stem* taller, with longer more spreading branches; *leaves* much larger, smooth; *flowers* about half the size of the foregoing. *Willd.*

3. P. *capensis*. Cape Lead-wort. Thunb. Prodr. 33. Willd. n. 3.—"Leaves stalked, oblong, nearly entire; glaucous beneath. Stem erect." *Thunb.*—Native of the Cape of Good Hope.

4. P. *zeylanica*. Ceylon Lead-wort. Linn. Sp. Pl. 215. Willd. n. 4. Ait. n. 2. Brown n. 1. (Lychnis indica spicata, ocymastri foliis, fructibus lappaceis oblongis, radice urente; Comm. Hort. v. 2. 169. t. 85.)—Leaves stalked, oblong-ovate, smooth, entire. Stem erect, round.—Native of the East Indies, and New Holland. It flowers in the stove from April to September. The *stem* is rather shrubby. *Flowers* white; with a long tube.

5. P. *rosea*. Rose-coloured Lead-wort. Linn. Sp. Pl. 215. Willd. n. 5. Ait. n. 3. Curt. Mag. t. 230. (Radix vesicatoria; Rumph. Amboin. v. 6. 453. t. 168.)—Leaves stalked, ovate, smooth, somewhat toothed. Joints of the stem tumid.—Native of the East Indies; said to have been introduced by Dr. Fothergill in 1777. It blooms in the stove almost all the year long; and is the most favourite species of its genus, on account of the delicate pale scarlet of its *flowers*, which form compound clusters at the ends of the branches. The *stem* is shrubby, four or five feet high, slender, and requiring support. *Leaves* recurved.

6. P. *scandens*. Climbing Lead-wort. Linn. Sp. Pl. 215. Willd. n. 6. Ait. n. 4. (Dentellaria lychnioides sylvatica scandens, flore albo; Sloane Jam. v. 1. 211. t. 133. f. 1.)—Leaves stalked, ovate, smooth. Stem zigzag, climbing. Native of the West Indies. It was brought into the stoves of this country very early, but is not much regarded at present, the *flowers* being white and not striking in their appearance. Sloane compares them to the common field Campion. The climbing, much more lofty *stem*, distinguishes it from the two last. Their *leaves* are variable, and afford no well-marked distinction.

7. P. *auriculata*. Auricled Lead-wort. Lamarck Dict. v. 2. 270. Willd. n. 7.—Leaves stalked, ovate-oblong, with scaly dots beneath. Footstalks auricled at their base, and clasping the stem.—Native of the East Indies. *Stem* shrubby, slender. *Leaves* obtuse, smooth above; contracted at their base. *Flowers* in short terminal spikes, resembling those of *P. rosea* in form, but in the dried specimen they had no appearance of a red colour. *Lamarck.*

8. P. *tristis*. Dark-flowered Lead-wort. Ait. n. 5.—"Leaves obovate, abrupt, smooth.—Native of the Cape of Good Hope, from whence it was sent to Kew by Mr. Masson, in 1792. This is a greenhouse shrub, flowering in May and June. We have seen no specimens of these two last species.

Plumbago, in *Gardening*, contains plants of the herbaceous, flowering, perennial kinds, of which the species cultivated are; the European leadwort (P. europæa); the Ceylon leadwort (P. zeylanica); the rose-coloured leadwort (P. rosea); and the climbing leadwort (P. scandens).

Method of Culture.—The first sort is increased by parting the roots in the autumn, when the stems decay, and planting them in a dry soil. They should afterwards be kept clean from weeds, and have proper support.

The three other sorts should be raised from seeds, which should be sown in pots in the spring, and plunged in hot-beds. They likewise may sometimes be raised by planting slips and cuttings in pots, and plunging them in the same sorts of hot-beds.

These are all ornamental flowering plants; the first in the pleasure-grounds, and the others in pots among hot-house collections.

Plumbago, in *Metallurgy*, a metalline recrement, separated in the purification of gold or silver with lead, and sticking to the sides of the furnace.

This is otherwise called *molybdæna*; and has the same virtue with litharge. See Molybdæna.

Plumbago seems to have been used, among the *Ancients*, for *Black* Lead (which see), and employed in making pencils for designing, &c.

The black lead used for this purpose, called "plumbago," and also "carbure of iron," by Werner "graphit," the "fer carbure" of Haüy, is a species of coal, or mineral carbon (see Coal), of a dark iron black colour, passing into steel-grey, and occurs in mass, in kidney-shaped lumps, and disseminated. It has a glistening metallic lustre; its fracture is small, somewhat curved foliated, approaching to scaly, or granular uneven: in the great it is slaty. It occurs generally in granular or scaly distinct concretions; takes a polish by cutting or rubbing; gives a dark lead-grey streak, and is unctuous to the feel, soft, and not very brittle. Spec. grav. 1.98 to 2.26. It does not flame when heated, nor can by itself to support combustion. After long exposure to a high heat in a muffle, its carbon is burnt off, and its earthy and metallic part remains behind. If one part of plumbago, and two of very caustic dry alkaline, be heated in a retort with the pneumato-chemical apparatus, the alkaline becomes effervescent, hydrogenous gas is obtained, and the plumbago disappears. This experiment proves, that the small quantity of water contained in the salt is decomposed, and that its oxygen, by combining with the carbon of plumbago, forms the carbonic acid. The sulphuric acid does not act upon plumbago, according to Scheele. Pelletier has observed, that 100 grains of plumbago, and four ounces of oil of vitriol, being digested in the cold for several months, the acid acquired a green colour, and the property of congealing by a very slight degree of cold. The sulphuric acid distilled from plumbago passes to the state of the sulphureous acid; at the same time that carbonic acid is obtained, and an oxyd of iron is left in the retort. The nitric acid has no action upon plumbago, unless it be impure. The muriatic acid dissolves the iron and clay which contaminate native plumbago. Messrs. Berthollet and Scheele availed themselves of this method to purify it. The liquor being decanted after digestion upon the plumbago, the residue is then washed and submitted to distillation to separate the sulphur. The muriatic acid alone has no action upon plumbago, but the oxygenated muriatic acid dissolves it; the result being a true combustion effected by the oxygen of the acid, and the carbon of the plumbago. If ten parts of the nitrate of pot-ash be fused in a crucible, and one part of plumbago be thrown upon it by a little at a time, the salt will deflagrate, and the plumbago will be destroyed. The matter which remains in the crucible consists of very effervescent

alkali, and a small portion of martial ochre. If plumbago be distilled with muriate of ammonia, the muriate sublimes, coloured by the iron. All these facts prove that plumbago is a peculiar combustible substance, a true charcoal combined with a martial basis. The purer kind of plumbago, according to Scheele and Berthollet, consists of about 90 *per cent.* of carbon and 10 of iron. An impure kind from Pluffier afforded Vauquelin

23	carbon
2	iron
37	alumine
38	silex
100	

The brilliant charcoal of certain vegetable substances, more especially when formed by distillation in close vessels, possesses all the characters of plumbago: and the charcoal of animal substances, possesses characters still more peculiarly resembling it. When animal substances are distilled by a strong fire, a very fine powder sublimes, which attaches itself to the inner part of the neck of the retort. This substance may be made into excellent black-lead pencils. Carbon may be formed in the earth by the decomposition of wood, together with pyrites; but the origin of plumbago, says M. Chaptal, is principally owing to the ligneous, and truly indecomposable, part of the wood, which resists the destructive action of water in its decomposition of vegetable substances. This mineral is found in primitive and transition rocks in England, Scotland, France, Spain, Germany, America, &c. Besides its use for pencils, the best for this purpose is that from Borrowdale, in Cumberland; it is sometimes used to lubricate machinery instead of oil, and to protect iron from rust. The hearths and plates of chimnies and other utensils, which appear very bright, owe their colour to plumbago. For this purpose Homberg long ago, *viz.* in 1699, directed 8lbs. of hog's-lard to be melted with a small quantity of water, with the addition of 4 oz. of camphor. When this last is fused, the mixture is taken from the fire; and while it is yet hot, a small quantity of plumbago is added to give it a leaden colour. When this is to be applied, the utensils must be heated to such a degree, that the hand can scarcely bear to touch them. In this state the composition must be rubbed on them, and afterwards wiped when the piece is dry. Those who prepare small shot, use black lead to polish or glaze it, by rolling or agitating them together with a quantity of plumbago. It is likewise used to make razor strops. When kneaded with clay, it makes excellent crucibles. One part of plumbago, three of argillaceous earth, and a small quantity of cow's dung very finely chopped, form an excellent lute for retorts; this lute is very refractory; and the glass will melt with the coverings changing its form. Aikin's Dict. Chaptal's Chem. vol. ii.

Pomet says, that plumbago was the sea-lead, *plumbum marinum*, of the ancients; who, he notes, took black-lead for a production of the sea, not a mineral, as it really is; but this is scarcely credible.

PLUMBAGO, in the *History of the Gems*, a word used by the Roman authors to express a blemish common to their worse kinds, and greatly debasing their value. It was a sort of blueish or blackish deadness in the stone, which mixed itself with the other colour, be that what it would, and rendered it dull and dead. The emerald was of all the gems the most subject to this fault; and in this case, its fine green colour was always rendered cloudy and blueish; and in some lights the stone appeared of a dusky greyish-blue, with no green at all in it. The Bactrian emeralds, which were in great esteem with the ancients, were often subject to this imperfection; and those of Cyprus, taken out of the copper mines, though subject to many other imperfections, were usually quite free from this.

PLUMBAGO, in *Mineralogy*, a name given by many authors to a sort of fossil, having very much the appearance of a lead-ore, but not such in reality.

It is called also galena, blende, and mock-lead. It is usually of a plated texture, and dark blackish-blue colour, like the lead-ores; but on trial it yields no metal. See GALENA and BLENDE.

PLUMBARIA, in *Ancient Geography*, an island situated on the coast of Spain, near the promontory Dianium, according to Strabo.

PLUMBATÆ, among the *Ancients*, a kind of scourge, the thongs of which were armed with lead.

PLUMBATÆ likewise signified leaden balls, used by soldiers to annoy the enemy with; whence the soldiers were called *martiobarbuli*.

PLUMBERY, formed of *plumbum*, *lead*, the art of casting, preparing, and working lead; and of using it in buildings, &c. See LEAD.

The lead used in plumbery is furnished from the lead-works in large ingots, or blocks, called pigs of lead, ordinarily weighing about a hundred pounds a-piece.

As this metal melts very easily, it is easy to cast figures of it, of any kind, by running it into moulds of brass, clay, plaister, &c. But the chief article in plumbery is the sheets, and pipes of lead. They are these which make the basis of the plumber's work in building; the process of these, therefore, we shall give a description of.

Method of casting large Sheets of Lead.—The lead destined for this use is melted in a large cauldron or furnace, usually built with free-stone and earth, fortified on the outside with a massive of shards and plaister. At the bottom of it is a place sunk lower than the rest, in which is disposed an iron pot, or pan, to receive what may remain of the metal after the sheet is run. The furnace is so raised above the area of the floor, as that the iron pot just rests on it.

To use the furnace, they heat it with wood laid within it; that done, they throw in the lead at random with the burning coals, to melt.

Near the furnace is the table or mould, on which the lead is to be cast. This consists of large pieces of wood, well jointed, and bound with bars of iron at the ends. Around it runs a frame, consisting of a ledge or border of wood, two or three inches thick, and one or two high from the table, called the *sharps*. The ordinary width of the tables is from three to four feet; and their length from eighteen to twenty feet.

This table is covered with fine sand, prepared by moistening it with a watering pot, then working it with a stick; and at last, to render it smooth and even, beating it flat with a mallet, and planing it with a slip of brass, or wood.

Over the table is a strike or rake of wood, which bears and plays on the edges of the frame, by means of a notch cut in either end of it; and is so placed, as that between it and the sand is a space proportionable to the intended thickness of the sheet. The use of this strike is to drive the matter, while yet liquid, to the extremity of the mould.

At top of the table is a triangular iron peel or shovel, bearing, before, on the edge of the table itself, and behind, on a tressel somewhat lower than the table. Its use is in conveying the metal into the mould; and the design of its oblique disposition is, that it may by that means be able to retain the metal, and keep it from running off at the fore-side,

where it has no ledge. Some of these peels are big enough to hold fifteen or sixteen hundred weight of lead, and even more.

Things being thus disposed, with a large iron ladle they take out the melted lead, coals and all, out of the furnace; and with this, mixed as it is, they fill the iron peel. When full, they take out the coals, and clear the lead with another iron spoon, pierced after the manner ot a scummer.

This done, they hoist up the lower part of the peel by its handle; upon which the liquid matter running off, and spreading itself on the mould, the plumber conducts and drives it to the extremity of the table, by means of the strike, which the workman passes along the ledges, and thus renders the sheet of an equal thickness.

The sheets thus cast, there remains nothing but to edge them, *i. e.* to planish the edges on both sides, in order to render them smooth and straight.

Method of casting thin Sheets of Lead.—The table or mould here used is of a length or breadth at discretion, only ledged on one side. Instead of sand, they cover it with a piece of woollen stuff, nailed down at the two ends, to keep it tight; and over this they lay a very fine linen cloth. The feet of the table are uneven, so that it does not stand horizontal, but moderately inclined.

Great regard is, in this process, had to the lead while melting, that it have the just degree of heat, so as it may run well, yet not burn the linen. This they judge of by a piece of paper; for if the paper take fire in the liquid lead, it is too hot; and if it be not shrunk and scorched a little, it is not hot enough.

Being then in its just degree, they have a strike, but different from that described in the former article; as serving both for peel and strike; both to contain and to conduct the liquid lead. It is, in effect, a wooden case without any bottom, only closed on three sides. It is pretty high behind, but the two sides, like two acute angles, still diminish to the tip, from the place where they are joined to the third or middle piece, where they are of the same height with it; *viz.* seven or eight inches high. The width of the middle makes that of the strike, which again makes that of the sheet to be cast.

The strike is placed at top of the table, which is before covered in that part, with a pasteboard, that serves as a bottom to the case, and prevents the linen from being burnt while the liquid is pouring in. The strike is so disposed on the table, as that the highest part looks to the lower end of the table, and the two sloping sides to the higher end.

The strike is now filled with lead, according to the quantity to be used; which done, two men, one at each side the table, let the strike descend down the table, or else draw it down with a velocity greater or less, as the sheet is to be more or less thick; the thickness of the sheet still depending on the promptitude with which the strike slides down the inclining mould.

The fine smooth sheets of lead, thus made, are sometimes used between the joints of large stones in great buildings, &c.

For the method of casting pipes, without soldering, see PIPE.

The solder which the plumbers use, is a mixture of two pounds of lead with one of tin. See SOLDER.

Plumber's work is commonly estimated by the pound or hundred weight; but the weight may be discovered by the measure of it, in the manner below stated. Sheet lead used in roofing, guttering, &c. is commonly between seven and twelve pounds weight to the square foot; but the following table shews by inspection the particular weight of a square foot for each of several thicknesses.

Thickness.	Pounds to a Square Foot.	Thickness.	Pounds to a Square Foot.
.10	5.899	.15	8.848
.11	6.489	.16	9.438
	6.554	$\frac{1}{6}$	9.831
	7.078	.17	10.028
	7.373	.18	10.618
.13	7.668	.19	11.207
.14	8.258	.2 = $\frac{1}{5}$	11.797
	8.427	.21	12.387

In this table the thickness is set down in tenths and hundredths, &c. of an inch; and the annexed corresponding numbers are the weights in avoirdupois pounds, and thousandth parts of a pound. So the weight of a square foot of $\frac{1}{10}$ or $\frac{10}{100}$ of an inch thick, is 5 pounds and 899 thousandth parts of a pound; and the weight of a square foot to $\frac{1}{6}$ of an inch thickness is 6 pounds and $\frac{831}{1000}$ of a pound. Leaden pipe of an inch bore is commonly 13 or 14 pounds to the yard in length.

Examples.

1. How much weighs the lead which is 39 feet 6 inches long, and 3 feet 3 inches broad, at $8\frac{1}{2}$ lbs. to the square foot?

Decimals.	Duodecimals.		
	39		
	3		
39.5			
$3\frac{1}{4}$	118	6	
	9	10	6
118.5			
9.875	128	4	6
	$8\frac{1}{2}$		
128.375	1024		
$8\frac{1}{2}$			
	64		
1027.000	$2\frac{5}{6}$		
64.1875	$0\frac{17}{48}$		
1091.1875	Answer $1091\frac{3}{16}$ lbs.		

2. What cost the covering and guttering of a roof with lead, at 18*s.* the cwt.; the length of the roof being 43 feet, and the breadth or girth over it 32 feet, the guttering 57 feet long, and two feet wide; the former 9.831 lbs., and the latter, 7.373 lbs. to the square foot? Ans. 115*l.* 9*s.* $1\frac{1}{2}$*d.* Hutton's Mensuration.

PLUMBING, among *Miners*, a term used to express the using a mine dial, in order to know the exact place of the work where to sink down an air-shaft, or to bring an adit to the work, or to know which way the load inclines when any flexure happens in it.

It is performed in this manner: a skilful person with an assistant, and with pen, ink, and paper, and a long line and a sun-dial, after his guess of the place above ground, descends into the adit or work, and there fastens one end of the line to some fixed thing in it; then the incited needle is let to rest, and the exact point where it rests is marked with a pen: he then goes on farther in the line still fastened, and at the next flexure of the adit he makes a mark on the line by a knot or otherwise; and then letting down the dial again, he there likewise notes down that point at which the needle stands in this second position. In this manner he proceeds from turning to turning, marking down the points,

and marking the line till he comes to the intended place this done, he afcends, and begins to work on the furface of the earth what he did in the adit, bringing the firft knot in the line to fuch a place where the mark of the place of the needle will again anfwer its pointing, and continues this till he comes to the defired place above ground, which is certain to be perpendicularly over the part of the mine into which the air-fhaft is to be funk.

PLUMBUM. See LEAD.

PLUMBUM *Corneum*, called alfo *Saturnus corneus*, in *Chemiftry*, is a metallic falt, formed by the precipitation of lead from its folution in nitrous acid with the marine acid, and all the neutral falts which contain it. It is thus called from its refemblance to the luna cornea. This falt may be made by other methods, and particularly by difengaging the volatile alkali from fal ammoniac by lead. In this way Mr. Margraaf makes the plumbum corneum, which he employs in the preparation of phofphorus. See LEAD.

Polisher

POLISHER, an inſtrument, called alſo a burniſher, uſed for poliſhing and burniſhing gold, ſilver, and other metals, when gilt or ſilvered; and matters of other kinds, proper to take a poliſh.

The poliſher is different in the different arts and manufactories. The gilders uſe an iron poliſher, to prepare their metals before gilding; and the blood-ſtone, to give them the bright poliſh after gilding.

The poliſher uſed by the makers of ſpurs, bits, &c. is part iron, part ſteel, and part wood. The inſtrument conſiſts of an iron bar, with a wooden handle at one end, and a hook at the other, to faſten it to another piece of wood held in the vice, while the operator is at work. In the middle of the bow, withinſide, is what they properly call the poliſher; which is a triangular piece of ſteel, with a tail, by which it is rivetted to the bow. What the cutlers call their poliſhers are a kind of wooden wheels, for grinding, made of walnut-tree, an inch thick, and of a diameter at pleaſure. They are turned by the great wheel; and it is on theſe they poliſh and ſmooth their works with emery and putty.

The poliſhers uſed in the manufacture of glaſs are very different from all theſe. They conſiſt of two pieces of wood; the one flat, covered with old hat; the other long and half round, faſtened on the former, whoſe edge it exceeds, on both ſides, by ſome inches: which ſerve the workman to take hold of, and to work it backwards and forwards by.

The poliſhers uſed by ſpectacle-makers are pieces of wood a foot long, ſeven or eight inches broad, and an inch and a half thick, covered with old caſtor hat, on which they poliſh the ſhell and horn frames their ſpectacle glaſſes are to be ſet in.

POLISHING, the art of giving a gloſs or luſtre to a thing; particularly a precious ſtone, marble, glaſs, a mirror, or the like.

For grinding and poliſhing ſteel, the grindſtones that are uſed are made to revolve, either vertically or horizontally, with a velocity ſo great, as to deſcribe ſometimes as much as ſixty feet in a ſecond. The ſteel is alſo, in ſome caſes, drawn backwards and forwards horizontally on a circular ſurface; and in order that the action may be equally diſtributed throughout the ſurface, it is allowed to revolve on an axis by means of the friction: its motion being confined to one direction by the action of a catch. Various ſubſtances, chiefly of mineral origin, are alſo uſed, on account of their hardneſs, as intermediate materials, for grinding and poliſhing others. Theſe are diamond duſt, corundum, emery, tripoli, putty, glaſs, ſand, flint, red oxyd of iron, or crocus martis, and prepared chalk. Theſe are ſometimes applied in looſe powder, and ſometimes fixed on wood, leather, or paper. Cuttle-fiſh bone and ſeal-ſkin are furniſhed by the animal kingdom; and Dutch ruſhes by the vegetable; theſe are employed chiefly in poliſhing wood or ivory. Marble is made ſmooth by rubbing one piece on another, with the interpoſition of ſand; the poliſhing blocks are ſometimes cauſed to revolve by machinery in a trough, in which the marble is placed under water, and are drawn at the ſame time gradually to and from the centre; or the ſlab itſelf, with the frame on which it reſts, is drawn ſlowly backwards and forwards, while the blocks are working in it. (See *Poliſhing of* MARBLE.) Granite is poliſhed with iron rubbers, by means of ſand, emery, and putty: but it is neceſſary to take care, during the operation, that the water, which trickles down from the rubbers, and carries with it ſome of the iron, may not collect below the columns, and ſtain them; an inconvenience which may be wholly avoided by employing rubbers of glaſs.

For the method of grinding and poliſhing optical lenſes, ſee GRINDING, LENS, and MIRROR.

POLISHING *of Glaſſes, Lenſes, &c.* ſucceeds the grinding of them.

The poliſhing of a mirror is the laſt preparation given it with emery or putty.

For an account of the methods recommended by various authors for poliſhing glaſs and metals in the conſtruction of teleſcopes, &c. ſee GRINDING.

For the poliſhing of diamonds, &c. ſee LAPIDARY; ſee alſo DIAMOND, and GEMS.

When plates of glaſs for looking-glaſſes and mirrors are prepared in the manner ſtated under LOOKING-*Glaſſes* and MIRROR, the next proceſs is that of poliſhing both ſurfaces to that perfect brightneſs which is obſervable in finiſhed mirrors, ſo that the rays of light may paſs through unimpaired to the ſilvering on the poſterior ſurface, and be reflected again from thence, according to the laws of catoptrics. The ſubſtance uſed to give this laſt poliſh is colcothar, imported from this country, and called "rouge d'Angleterre," or "Potée." It is the reſidue left in the retorts of the aquafortis-makers, and when well waſhed and levigated conſiſts of little elſe than a red and perfect oxyd of iron. The poliſhing inſtrument is a block of wood covered with ſeveral folds of black cloth with carded wool between each fold, ſo as to make a firm elaſtic cuſhion. This block has a handle for the workman to hold; for the whole of this part is done by hand and not by machinery, as the latter would work too uniformly, and not allow of that variation of preſſure and thoſe finiſhing touches which are required to bring every part of the glaſs to exactly the ſame height of poliſh. But to increaſe the preſſure of the poliſher, without fatiguing the workman, the handle is lengthened by a wooden ſpring bent to a bow, and three or four feet long, which at the other extremity reſts againſt a fixed point in a beam placed above. The plate being fixed on the table by plaſter, he then moiſtens the poliſher with a wet bruſh, covers it with colcothar, and begins his operation by working it backwards and forwards over the ſurface of the plate. Much practical ſkill and dexterity is required to give an uniform and high degree of poliſh over the ſurface of a large plate, as it muſt be done by ſeparate portions, and the finiſhing touches given with great care. The glaſſes of moderate ſize are completed in four portions from corner to corner, the centres of which intermingle ſo as to leave no part untouched, but the larger glaſſes require additional poliſhing in the centre. When one ſide is completed, and the reverſe is about to be done, the poliſhed ſide, now the undermoſt, is entirely covered with the red colcothar, to prevent the dazzle reflected from the white plaſter, which

would prevent the workman from judging fo accurately of the ftate of the furfaces on which he is employed. When both fides of the glafs are thus brought to the fame perfection of polifh, the operation is finifhed by infpecting the glafs, firft cleaning both furfaces, and laying it, each fide alternately upwards, upon a dark blue or black cloth, admitting only a moderate light, and if any part appear lefs highly finifhed than the reft it is retouched by a fmall hand-polifher and colcothar as before.

When a number of fmaller pieces of glafs, fuch as are ufed only for chamber or fimilar mirrors are to be polifhed, they are laid together on the table, and feveral of them polifhed at a time. But as thefe confift of pieces often of unequal thicknefs, though their furfaces have been rendered perfectly flat by the previous grinding, if they were fimply placed fide by fide, and fixed on the table by plafter as ufual, the polifher would not work well over fuch a variety of heights, and would act chiefly on the edges of each piece of plate. Therefore they are all firft arranged on a large fmooth plate, finifhed all but the polifhing, and previoufly wetted, and plafter is poured upon them by which they are fixed together, and then when taken off, the furfaces which were in contact with the plate are perfectly level with each other, and the polifhing goes on with the fame eafe as on an entire plate.

For an account of the next operation, which is that of *Silvering*, fee that article, and LOOKING-*Glafs*.

Porcelain

PORCELAIN, or PURCELAIN, a fine ſort of earthen-ware, chiefly manufactured in China, and thence alſo called *china*, or *china-ware*; but brought into Europe from other parts of the Eaſt, eſpecially Japan, Siam, Surat, and Perſia.

The Chineſe call it *tſe-ki*. The word porcelain is but little known there; except among a few workmen and mer-

chants; and ſeems derived from the Portugueſe, *porcelana, a cup.*

Scaliger and Cardan, though generally of contrary ſentiments, are yet agreed, that what the Romans called *vaſa murrhina, murrina,* and *murrea,* which were firſt ſeen at Rome in Pompey's triumph, and afterwards became ſo very precious, were the porcelain of our times.

This may be true; but if the opinion be only founded on Pliny's deſcription of thoſe veſſels, one would rather take them to have been made of a kind of precious ſtones, of a whitiſh colour, but variouſly veined and variegated, found in ſome parts of Parthia. Oriens murrhina mittit, &c. Plin. Hiſt. Nat. lib. xxxvii. cap. 2. See MURRHINE.

Be this as it will, it is certain, that both Cardan and Scaliger are miſtaken when they tell us that porcelain is made of eggs and ſea-ſhells, beaten ſmall, and buried under ground for eighty or one hundred years. The account we ſhall here give will put that matter out of all queſtion.

It is not known who was the inventor of porcelain; the Chineſe annals, which commonly contain every thing in any reſpect memorable, are perfectly ſilent about it; nor do we know much more of the time of its invention: only it is certain it muſt have been before the beginning of the fifth century, the annals of Feou-leam relating that from the ſecond year of the reign of the emperor Tam, about the year of Chriſt 442, the workers in porcelain of that province had alone furniſhed the emperors with it.

Porcelain is now made chiefly, ſome ſay wholly, at King-te-tching, a large and populous village near Jao-tcheou, in the province of Kian-gſi. See KING-TE-TCHING.

There is ſome indeed made in the province of Quang-tong and Fo-kien; but it is of little account, being far inferior in beauty and value to the porcelain of King-te-tching. That of Fo-kien is perfectly white without either gloſs or painting. Attempts have been made to remove the manufacture from King-te-tching to Pekin, and other places, but in vain; the porcelain made in the new manufactories never coming up to that of the old; ſo that King-te-tching has the honour of ſupplying the greateſt part of the world with this commodity. F. du Halde aſſures us, that even the Japaneſe come to China for it.

There is a current opinion among the Chineſe themſelves, that the porcelain ware of former times was greatly ſuperior to that which they make at preſent; and that the burying china in the earth for a long time adds to its beauty; but all this is founded on error. The truth is, that our merchants beat down the price of the ware, and thereby compel them to make a worſe kind in general; but they are able to do as fine things now as ever. What gave birth to the opinion, that burying porcelain ware made it good, was, that finer pieces than ordinary are ſometimes found buried. Theſe are all precious vaſes, which the poſſeſſors buried by way of ſecurity in the times of civil war; and it is no wonder, that there are none but of the fineſt kind found buried on theſe occaſions.

PORCELAIN, *Manufacture of.* Porcelain makes a very curious article in commerce, and not leſs ſo in natural hiſtory. Its manufacture for a long time paſſed as a myſtery in Europe; and that in ſpite of all the endeavours of the Jeſuit miſſionaries to penetrate into the ſecret. The veil, however, was at length drawn: and in a letter of F. d'Entrecolles to F. Orry, from Jauchew, dated September 1, 1712, and publiſhed in French, the whole proceſs is deſcribed in all its circumſtances; with an extract of which we ſhall here gratify the curious reader. In the manufacture of porcelain there are four things to be conſidered, *viz.* the matter it is made of; the art of forming the veſſels, and other works; the colours with which it is painted; and, laſtly, the baking or giving it the proper degree of fire. Each of which will make the ſubject of a ſeparate article.

PORCELAIN, *Materials of.* There are two kinds of earths, and as many kinds of oils, or varniſhes, uſed in the compoſition of porcelain. The firſt earth, called *kaolin,* (which ſee,) is intermixed with different corpuſcles; the ſecond, called *petunſe,* or *petuntſe,* (which ſee,) is a plain white, but exceedingly fine, and ſoft to the touch. They are both found in quarries twenty or thirty leagues from King-te-tching; and hither theſe earths, or rather ſtones, are brought in a number of little barks, inceſſantly paſſing up and down the river of Jao-tcheou for that purpoſe. The petunſes are brought in form of bricks; having been ſo cut out of the quarries, where they are naturally pieces of a very hard rock. The white of the beſt petunſe is to border a little on green.

The firſt preparation of theſe bricks is, to break and pound them, firſt into a coarſe powder with iron mallets, then in mortars with peſtles that have ſtone heads, armed with iron, and wrought either with the hand, or with mills.

When the powder is rendered almoſt impalpable, they throw it in a large urn full of water, ſtirring it briſkly about with an iron inſtrument. After the water has reſted a little while, they ſkim off from the top a white ſubſtance formed there, of the thickneſs of four or five fingers, and diſpoſe this ſcum or cream in another veſſel of water. They then ſtir again the water of the firſt urn, and again ſkim it, and thus alternately, till there remain nothing but the gravel of the petunſes at bottom; which they lay afreſh under the mill, for a new powder.

As to the ſecond urn, in which are put the ſkimmings of the firſt, when the water is well ſettled, and become quite clear, they pour it off; and with the ſediment, collected at bottom in form of a paſte, fill a kind of moulds: whence, when almoſt dry, they take it out, and cut it into ſquare pieces, which are what they properly call *ſquare* petunſes; reſerving them to be mixed with the kaolin in the proportion hereafter aſſigned.

Theſe ſquares are ſold by the hundred, but it is very rare to meet with them unfalſified; the workmen, who, like the reſt of the Chineſe, are arrant knaves in their dealings, uſually mixing refuſe along with them; ſo that they are commonly obliged to purify them before they can be employed.

The kaolin, which is the other earth uſed in porcelain, is much ſofter than the petunſe, when dug out of the quarry; yet it is this, which, by its mixture with the other, gives the ſtrength and firmneſs to the work. F. d'Entrecolles obſerves that ſome Engliſh or Dutch, having procured ſome petunſes to be bought privately; upon their attempting to make porcelain at their return into their own country, could not ſucceed for want of taking kaolin along with it; which the Chineſe being appriſed of, ſaid, humorouſly, "That the Europeans were wonderful people, to go about to make a body, whoſe fleſh was to ſuſtain itſelf without bones." The mountains whence the kaolin is dug, are covered without-ſide with a reddiſh earth. The mines are deep, and the matter is found in glebes or clods. The author is of opinion, that the white earth of Malta is not much different from the kaolin, except that it wants the ſilvered particles. The preparation of kaolin is the ſame with that of the petunſes, except that the matter being leſs hard, leſs labour is required.

The oil or varniſh, which makes the third ingredient in porcelain, is a whitiſh liquid ſubſtance; this is drawn from the hard ſtone, of which the petunſes are formed; that

which is the whiteſt, and whoſe ſtains are the greeneſt, being always choſen for this purpoſe. The manner of preparing the oil is thus: the petunſes, being waſhed, undergo the ſame preparations as for making the ſquares; excepting that the matter of the ſecond urn is not put in moulds, but the fineſt part of it taken to compoſe the oil. To a hundred pounds of this matter they caſt a mineral ſtone, called *ſhekau*, or *kekao*, reſembling our alum; this ſtone is firſt heated red-hot, and thus reduced in a mortar into an impalpable powder; and ſerves to give the oil a conſiſtence; which, however, is ſtill to be kept liquid.

The oil of lime makes the fourth ingredient; the preparation of which is much more tedious and circumſtantial. They firſt diſſolve large pieces of quick-lime, and reduce it to a powder, by ſprinkling water on it; on this powder they lay a couch of dry fern, and on the fern another of the ſlaked lime, and thus alternately, till they have got a moderate pile; which done, they ſet fire to the fern; the whole being conſumed, they divide the aſhes that remain on new couches of dry fern; ſetting them on fire as before. And this they repeat five or ſix times ſucceſſively, or even more; the oil being ſtill the better, as the aſhes are oftener burnt.

In the annals of Feou-leam it is ſaid, that inſtead of fern they anciently uſed the wood of a kind of medlar-tree; and that it was this gave the ancient porcelains that admirable hue, which the moderns cannot come up to for want of that wood. But this is become ſcarce in the country, and is no longer uſed. It is certain, however, the quality of the fern and lime contribute very much to the goodneſs of the oil.

A quantity of theſe aſhes of fern and lime is now thrown into an urn full of water; and to a hundred pounds of aſhes is added a pound of ſhekau, which diſſolves therein. The reſt being performed after the ſame manner as in preparing the earth of the petunſes, the ſediment found at the bottom of the ſecond urn, and which is to be kept liquid, is what they call the *oil of lime*; which the Chineſe eſteem as the ſoul of the former oil, and which gives the porcelain all its luſtre.

This oil is eaſily ſophiſticated by adding water to increaſe the quantity; adding, at the ſame time, proportionably of the ſame ſhekau to maintain the conſiſtence. Ten meaſures of oil of petunſe uſually go to one of lime. To have the mixture juſt, the two oils ſhould be equally thick.

Porcelain *Veſſels, forming of.* The firſt thing is to purify the petunſe and kaolin; which, for the firſt, is done after the manner already deſcribed in preparing the ſquares. For the ſecond, as its ſoftneſs makes it diſſolve eaſily, it is ſufficient, without breaking it, to plunge it in an urn full of water in an open baſket. The dregs that remain are perfectly uſeleſs, and are emptied out of the work-houſe when a quantity is got together.

The work-houſes are properly vaſt yards walled round, with ſheds and other conveniencies for the workmen to work under; as well as other buildings for them to live in. It is almoſt inconceivable what number of perſons are employed in theſe works; there being ſcarce a piece of porcelain but paſſes through above twenty hands, before it comes to the painter's work-houſe; and above ſixty before it be brought to perfection.

To make a juſt mixture of petunſe and kaolin, regard muſt be had to the fineneſs of the porcelain to be made; for the finer porcelains, they uſe equal quantities; four parts of kaolin to ſix of petunſe, for moderate ones; and never leſs than one of kaolin to three of petunſe, for the coarſeſt.

The hardeſt part of the work is the kneading and tewing the two earths together; which is done in a kind of large baſons, or pits, well paved, and cemented, in which the workmen trample continually with their feet, relieving one another, till the maſs be well mixed, grow hard, and become of the conſiſtence required to be uſed by the potter.

The earth, when taken out of the baſons, is kneaded a ſecond time, but piece-meal, and with the hands, on large ſlates for the purpoſe; and on this preparation, in effect, it is, that the perfection of the work depends; the leaſt heterogeneous body remaining in the matter, or the leaſt vacuity that may be found in it, being enough to ſpoil the whole. The ſmalleſt grain of ſand, nay, ſometimes a ſingle hair, ſhall make the porcelain crack, ſplinter, run, or warp.

The porcelain is faſhioned or formed either with the wheel, like our earthen ware, or in moulds. See Pottery.

Smooth pieces, as cups, urns, diſhes, &c. are made with the wheel. The reſt, *i. e.* ſuch as are in relievo, as figures of men, animals, &c. are formed in moulds, but finiſhed with the chiſſel.

The large pieces are made at two operations; one half of the piece is raiſed on the wheel by three or four workmen, who hold it till it have acquired its figure; which done, they apply it to the other half, which has been formed in the ſame manner; uniting the two with porcelain earth, made liquid by adding water to it, and poliſhing the juncture with a kind of iron ſpatula.

After the ſame manner it is that they join the ſeveral pieces of porcelain formed in moulds, or by the hand; and after the ſame manner they add handles, &c. to the cups, and other works formed with the wheel.

The moulds are made after the manner of thoſe of our ſculptors; *viz.* of divers pieces, which ſeverally give their reſpective figure to the ſeveral parts of the model to be repreſented; and which are afterwards united to form a mould for an entire figure. The earth they are made of is yellow and fat, dug out of its proper quarries, of which there is abundance about King-te-tching. It is kneaded like potters' earth, and when ſufficiently mellow, fine, and moderately dry, beating it ſtoutly, they form it into moulds, according to the works required, either by hand, or on the wheel. Theſe moulds are ſold very dear, but they laſt a long time.

All the works made in moulds are finiſhed by the hand, with ſeveral inſtruments proper to dig, ſmooth, poliſh, and to touch up the ſtrokes that eſcape the mould; ſo that it is rather a work of ſculpture than of pottery. There are ſome works on which relievos are added, ready made, as dragons, flowers, &c. others that have impreſſions in creux; which laſt are engraven with a kind of puncheons. In the general, all porcelain works are to be ſheltered from the cold, their natural humidity making them liable to break when they dry unequally.

To conceive the number of hands each piece of porcelain paſſes through before it is perfect, we ſhall cloſe this article with what F. d'Entrecolles inſtances of a common tea-cup, before it be fit for the painter. The cup begins with the potter, who has the management of the wheel, where it acquires its form, height, and diameter. This operator has only three farthings ſterling for a plate furniſhed with twenty-ſix cups; accordingly, they go out of his hands exceedingly imperfect, eſpecially towards the feet, which are only unformed lumps of earth, to be afterwards cut with a chiſſel, when the cup is dry. When it comes from the wheel, the cup is received by a ſecond workman, who fits it to its baſe. A third takes it immediately from him, and applies it on a mould, to bring it to its true form. This mould is on a kind of lathe. A fourth workman poliſhes the cup with a chiſſel, eſpecially about the edges; and brings it to the thinneſs neceſſary to make it tranſparent; in doing which, he moiſtens

it from time to time, left its drynefs fhould make it break. When of its proper thicknefs, another workman turns it gently on a mould, to fmooth its infide; taking great care that it be done equably, left any cavity be formed, or it warp. Other workmen add fome ornaments in relievo; others, impreffions in creux; others, only handles; as the quality of the cup requires. At laft, they round and hollow the foot on the infide with the chiffel; which is the function of a particular artift, who does nothing elfe.

This multiplicity of workmen is fo far from retarding the work, that it is found, by experience, to go on the fafter for it; as well as to be the better done; each workman, by a continual attention to the fame thing, becoming very dexterous at it; befides faving the time of changing inftruments, &c.

Porcelain, *Painting of*. The Chinefe painters, efpecially thofe that meddle with human figures, our author obferves, are all bad workmen; he adds, that the defect is fcarcely any where fo fenfible as in the whapey, or porcelain painters, among whom, fetting afide flowers and landfcapes, which are fometimes tolerable, the greateft mafters are not to be compared to ordinary apprentices among the Europeans, for the beauty and juftnefs of defign. But it is otherwife with the colours thefe whapey ufe; which are fo exceedingly lively and brilliant, that there are but little hopes our workmen fhould ever come to vie with them.

The painting work is diftributed among a great number of workmen, in the fame laboratory: to one it belongs to form the coloured circle about the edges of the porcelain; another traces out flowers, which another paints: this is for waters and mountains alone; that for birds and other animals; and a third for human figures.

There are porcelains made of all colours: both with regard to the grounds, and to the reprefentations upon them. As to the colour of landfcapes, &c. fome are fimple; fuch are all blues, which are thofe moft ufually feen in Europe; others are mixed up of feveral tints; and others, again, are heightened with gold.

The Chinefe, for a great many ages, ufed only white porcelain. The firft colour they employed was blue, and after that they came into the ufe of all the reft. Their ancient blues were prepared by themfelves from a kind of lapis lazuli; but we now fupply them with the fmalt fo much cheaper, that it is no longer worth their while to make it themfelves. They ufed to prepare this only by giving a gentle calcination to the ftone, and then beating it to powder, and grinding it to the utmoft finenefs in mortars of unglazed porcelain ware, with peftles of the fame.

The fine deep blue of the old porcelain ware of China is much valued by the curious; and it is much lamented, that the fame colour is not ufed at this time. The art feems at prefent to be loft; but perhaps it might be recovered by trials.

It is certain that the Chinefe have cobalt among them, and very probably they ufed a blue colour prepared from this, before they had any commerce with us: notwithftanding all the conjectures about their materials for colouring, this feems the moft probable fubftance; and there is a way of preparing a colour from this, much fuperior to that now in ufe, which we call fmalt.

Cobalt is a mineral containing arfenic, and a blue vitrifiable earth. The common way of preparing fmalt is, by roafting this cobalt in a reverberatory fire. This difpofes it to vitrify, and drives off the arfenic it contains in fumes, which, collected at the top, form true flowers of arfenic. It is very certain, however, from experiments, that if this arfenic could be preferved in the cobalt, the fmalt would be of a much finer colour; for there are fome kinds of cobalt which yield fmalt without previous roafting; and as the arfenic is in a great meafure contained in thefe, the fmalts are much finer coloured.

Arfenic added to fmalt, while in fufion, greatly exalts its colour alfo; and there is a way of procuring fmalt from cobalt without fire, only by diffolving it in an acid, and precipitating that folution with oil of tartar. The fmalt thus precipitated to the bottom, is of a much finer colour than any prepared by fire; but it is much more expenfive, and prepared in lefs quantity. It is very poffible that the Chinefe might have the art of making this kind of fmalt before they knew us, and that to this was owing the fine blue of their porcelain ware: but when we trafficked with them, and they purchafed fmalt fo much cheaper of us than they could make it themfelves, they naturally difcontinued the manufacture of their own finer kind, without confidering how greatly inferior the colour was which the other yielded. If this be the cafe, it will be eafy to revive this art, and the adding the true old china blue to our European manufactures, in imitation of porcelain, may give them a value which they have not at prefent.

The red, which the Chinefe ufe, is made of our green vitriol, or common copperas, which they call *tfa-fan*. They put about a pound of this into a crucible; and lute on this another crucible inverted: this laft has a hole cut in the top, which they keep covered or open at pleafure. They fet this crucible in a furnace of bricks, fo contrived, as to throw all the flame upon the lower veffel, in the way of our chemifts' reverberatory furnaces. They make a large fire of charcoal all round it, and obferve the hole at the top; for fo long as there afcend thick black fumes through that, the matter is not fufficiently calcined. They watch the going off of this fume, and when there appears in the place of it a fine and thin cloud, they take away the crucible, the matter being then fufficiently burnt. They try this, however, by taking a little out, and examining the colour; if it is not fufficiently red, they let it remain longer in the fire. When they find that it is of a good colour; they take away the fire, and leave the veffels to cool; this done, they find a cake of red matter at the bottom of the crucible, and a quantity of a finer powder about its fides. They keep thefe feparate, the latter being the pureft, the fineft, and the brighteft colour.

One pound of copperas affords about four ounces of this colour, and this is the red which they manage in different fhades, and vary fo much. See *Blown* Red.

The Chinefe have alfo a white colour, which they ufe in their figures painted on the china: the ware itfelf is naturally white, and the varnifh, or oil of ftone, is a great addition to its whitenefs all over. But they have yet a way of making a much brighter and finer white than thefe, as may be feen in moft of the fine china-ware, where there is any white in the figures. This white is made in the following manner: they collect on the fhores of their rivers a fort of flint or agate, which is of a whitifh hue, without veins, and tolerably tranfparent. It approaches very much to the nature of cryftal, and probably cryftal may be found to fupply its place with us. They calcine this ftone to a white powder, and to every ounce of this, when ground in their porcelain mortars to an impalpable finenefs, they add two ounces of cerufs in fine powder: this they mix with the varnifh, and lay on in the common way of other colours. This white mixture ferves not only for the colouring white, but it is the bafis of feveral other of thofe beautiful colours which we fee on the china-ware, and which our manufacturers have been often perplexed what to make of. Their green colour

is made of copper rusted with acid; and their fine deep violet colour is made of this green, by adding to it a due proportion of this white. It is not to be supposed that this effect is produced according to the common laws of mixing colours among our painters, for then the white and green would only make a paler green. But copper being a metal that as well gives a fine blue as a fine green, according to the nature of the substances it is mixed with, the white in this case alters the very nature of the green, and converts it into that fine and deep violet blue, which we may draw from copper by means of any of the volatile alkalies, such as spirit of sal ammoniac, spirit of hartshorn, spirit of urine, or any the like liquor. The workmen know how to bring this blue to any degree, by putting in different proportions of the two colours. There is not any admixture of them, that will not produce a blue of some kind; but always the more of the green colour is used, the deeper the blue will be, and the less the paler. The yellow is made of an admixture of several drachms of this white, and three drachms of copperas, or more if they desire the colour to be deeper.

Most of these colours are mixed with gum water, for application; with a little salt-petre, sometimes cerufs, or copperas, but more usually copperas alone, being first dissolved in the water. Indeed for porcelain, that are to be quite red, the colour is usually applied with oil; *i. e.* with the common oil of the porcelain, or another made of the white flints.

These colours are laid upon the vessels when they have been once baked, but they do not appear till the second baking is over in their proper shades or tinges, and sometimes scarcely at all.

The black china called *umiam*, is much esteemed in the East, and particularly when it is ornamented with gold; this colour looking better with that ornament than any other. The black is always laid on when the porcelain is first dried, and is prepared by mixing three ounces of the fine deep blue, with seven ounces of that fine varnish which they call *oil of stones*. This admixture gives a fine deep black; but the proportion is varied, as the colour is designed to be more or less deep. When the colour is thoroughly dry, the vessels are baked, and when this is done, the gold is laid on, and the whole is baked again in a particular furnace made for this purpose.

The gold on this ware is never laid on alone, but managed in the following manner: they grind it in water to a fine powder, and leave it to dry in the shade; they then mix with every ten grains of gold one grain of cerufs, and incorporating the whole with gum-water, they lay it on in the manner of other colours. See GILDING *of China-ware.*

If they would have the black degenerate into blue, they need only add less of the blue, and a little of the cerufs and agate white before described. They have two peculiar ways of applying the red, besides the common one, both which require a nice workman, and make the ware come very dear. They call one of these oils *red*, and the other *blown* red, which is very rare and of great price.

There is likewise a kind of marbled porcelain, called by the Chinese, who are very fond of it, *tsou tchi.*

It is generally plain white, sometimes blue, and has exactly the appearance of a piece of china which had been first broken, and then had all the pieces cemented in their places again, and covered with the original varnish. The manner of preparing it is easy, and might be imitated with us. Instead of the common varnish of the china-ware, which is made of what they call oil of stone and oil of fern mixed together, they cover this with a simple thing made only of a sort of coarse agates calcined to a white powder, and separated from the grosser parts by means of water, after long grinding in mortars. When the powder has been thus prepared, it is left moist, or in form of a sort of cream, with the last water that is suffered to remain in it, and this is used as the varnish. Our crystal would serve fully as well as these coarse agates, and the method of peparation is perfectly easy.

The occasion of the singular appearance of this sort of porcelain is, that the varnish never spreads evenly, but runs into ridges and veins. These often run naturally into a sort of mosaic work, which can scarcely be taken for the effect of chance. If the marbled china be desired blue, they first give it a general coat of this colour, by dipping the vessel into a blue varnish; and when this is thoroughly dry, they add another coat of this agate-oil. See PARTY-*China.*

There are several other kinds of porcelain; but they are such as are rather for curiosity than use: the prettiest are the magic porcelains, whose colours only appear when filled with water, or some other clear liquor. These are made double; the outside is white, and all laid out in compartiments; the inside is a solid cup of coloured porcelain; though the cup is sometimes of glass, which has a better effect than porcelain.

The Chinese called this sort of china-ware *kiatsim*, that is to say, the concealed blue china.

The art is now in a great measure lost; but there may be some guess made as to the manner in which it might be done at this time. The vessels which are to be made in this manner must be very thin: the colour must be laid on in the form of fish, or other animals or figures, on the inside, after the vessel has been once baked. After this colour has had time to dry, the inside of the vessel must have a second coat of the same earth, or stone-ware, of which the vessel is made; and over this a varnish of the common kind. The consequence of this will be, that the figures of the fish, in a very strong colour, will be buried between two coats of the ware, which together form a complete vessel. The outside is then to be ground down almost to the figures, and when they begin to appear, a new coat of the varnish must be laid over this. The figures will then be obscure, and scarcely, if at all, perceivable; but on filling the vessel with water, the transparence of the sides will be taken off, and the liquor will make a sort of foil behind, which will throw out the figures of the fish. This might be done in any ware tolerably clear and transparent. The porcelain of China would succeed better with it; but the pains and nicety required are too great, and all the attempts lately made by them have miscarried.

The Chinese make a great variety of figures on the surfaces of the vases of white china-ware, and there is one kind of this greatly in esteem among them, in which there are flowers and other figures; yet the surface is quite smooth, and the substance extremely thin. The manner of making it is this; they first form the vessel of the finest materials, as thin as they can; then, when they have polished it, inside and out, at the wheel, they put into it a stamp of its own shape, but cut with all these figures: they press this down so firmly on the yet moist vessel, that the impression is received in a very perfect manner; and if the shape of the vessel be at all hurt, they take it into the wheel again to restore it. They then finish it with the knife and scissars; and when they have made it as perfect as can be, they cover it with the fine white varnish within and without. This fills up all the cavities of the impression, and gives a perfectly smooth and even surface; yet the thickness of this varnish

in the traces of the figures gives it a different white, and the whole figures are as finely and accurately feen, as if painted on the outfide. This is an artifice that might eafily be brought to bear among us, and feveral of our finer wares would make a pretty figure with it.

There are many things practifed by the Chinefe in their colouring and forming the feveral kinds of porcelain, which may be well brought into ufe among us, and give a new value to our own wares, even though we fhould never arrive at their art of making the thing itfelf. One kind of colouring eafily introduced among us, would be what they call *hoan ton hoan*. This produces veffels of great beauty and price, and is done in this manner. The matter of which the veffels are made, for this purpofe, need not be fine; they ufually take any of the common veffels baked, without having been varnifhed, and confequently fimply white, and without luftre. When thefe are intended to be of one fimple colour, they need only be plunged into a liquid varnifh of oil, as the workmen there call it, coloured with fuch ingredients as will ftrike the moft lively tinges; but if it is to be coloured in compartiments, as is ufually the cuftom with this fort of china, it is to be done by the pencil. The ufual way is to paint thefe in pannels, one green, another blue, and fo on, and they make a very agreeable appearance. There requires no more to this, than the laying on the colours tolerably thick with a large pencil; but if the pictures of animals and plants are to be given, they are to be done with the moft permanent colours, and the veffel being again well baked, becomes very beautiful.

The Chinefe, who are deceivers in every thing, find the way of cheating very much in regard to this fort of china-ware. They paint the flowers of plants, and fome parts of the birds, &c. in very bright colours, after the veffel has been baked. Vermilion is a fine colour, which they often add on this occafion; but they cannot ufe this before the baking, becaufe it would be deftroyed by the fire. Thefe colours which are laid on afterwards cannot laft, but foon rub off in the wiping, or ufing the things; the others laft for ever; for they are laid on with the greateft heat of all, the veffels being put into the fame furnaces to lay on thefe, as the other things are baked in for the firft time.

Salt-petre, and powder of flints, are generally the things added to the colours thus laid on, to make them penetrate, and run properly. Thus, for the fine deep violet colour, which makes the greateft figure of all others on this ware, they mix together equal quantities of the fine azure, the powder of flints and falt-petre, all firft powdered feparately till perfectly fine; this is tempered with water, and then laid on with a pencil, and though it looks rough at firft, it comes out of the furnace of as beautiful a gloffy hue as any thing can be conceived. The yellow is made by mixing together three ounces of cerufs, and three ounces of powdered flints, and adding three, four, or more drachms of the red copperas, till the whole is of the proper degree of colour.

The white is compofed only of powder of flints and cerufs, with a fmall admixture of the falt-petre, or it will fucceed tolerably well without. Thefe are all the particulars neceffary to be obferved for the making a fort of porcelain of great beauty, in which the nature of the ware itfelf is not concerned; fo that it feems eafy to imitate it with any of our own wares. Obf. fur les Coûtumes de l'Afie, p. 320, &c.

The feveral kinds of porcelains above-mentioned, being quite painted, with their feveral colours, and all the colours dry, are to be polifhed, to prepare them to receive the oil or varnifh; which is done with a pencil of very fine feathers, moiftened with water, and paffed *lightly* over, to take off even the fmalleft inequalities.

The oiling or varnifhing is the laft preparation of the porcelain, before it be carried to the oven: this is applied more or lefs thick, and feldomer or oftener repeated, according to the quality of the work. For thin fine porcelain, they give two very thin couches: to others one; but that one equivalent to the other two. There is much art in applying the varnifh, both that it be done equally, and not in too great quantity. The couches on the infide are given by afperfion, *i. e.* by cafting in as much varnifh as is neceffary: thofe on the outfide by immerfion, or by plunging the pieces in a veffel of oil.

It muft be obferved, that the foot is not yet formed, but continues in a mere mafs, till the work has been varnifhed: it is at length finifhed on the wheel, and when hollowed, a little circle is painted in it, and fometimes a Chinefe character. This painting being dry, the foot is varnifhed, and the work now carried to the oven to be baked.

The varnifh they lay on is fo thick, that it often hides the colours, till the baking afterwards brings them out again: this is the cafe with the fine deep blues; we fee none on the beft china; it is all hid under the coat of white, and the veffel appears plain, till it has paffed through the fire again; but then the colour appears deeper than when at firft laid on. See HOACHE.

The china varnifhes have been always famous; the manner of making which is faid to be as follows: Take crude varnifh, fixty ounces; common water, the fame quantity: mix them well together till the water difappears; afterwards put this into a wooden veffel five or fix palms long, and two or three broad; mix them together with a wooden fpatula, for a whole day in the fummer's fun, for two days if in the winter, and afterwards keep it in an earthen veffel, covered with a bladder. The water will not feparate again: this is called the fun varnifh.

The oil of wood, called by the Portuguefe *azeile de pao*, is made in the following manner: Take twenty ounces of that oil, which they call oil of wood; and ten drachms of the oil of the fruit; boil thefe a little together, and the oil will look yellow; then let it cool, and add to it five drachms of quick-lime powdered. To make the firft grounds, called *camifeca*, take fwine's blood and quick-lime powdered, of each an equal quantity; fpread this mixture upon the wood, and when it is dry, fmooth it with pumice-ftones.

To make the black varnifh: Take the varnifh prepared in the fun, fixty ounces; ftone black alum (fuppofed to be a fort of copperas) diffolved in a little water, three drachms; and feventy drachms of lamp oil, called by the Portuguefe *azeile de Candea*. Thefe things are all to be mixed together in a wooden veffel, putting the lamp oil in at twice, and ftirring the whole together with a wooden fpatula.

The pitch-coloured varnifh is made in the following manner: Take oil of wood, crude, forty drachms, called *da pao;* of the lamp oil, called *da Candea*, crude, forty drachms; mix them together in the fun in a wooden veffel, in the fame manner as the common varnifh and water are ordered to be mixed in the firft procefs.

To make the red varnifh: Take ten drachms of cinnabar, twenty drachms of prepared varnifh, and a little lamp-oil; mix them all together.

To make a yellow varnifh: Take of the yellow colour ten drachms, prepared varnifh thirty drachms, a little lamp-oil; mix all together.

To make the varnifh of a mufk colour: Take of the red varnifh ten drachms, and of the black varnifh four drachms; mix them well together. Phil. Tranf. N° 261. p. 524.

These are the accounts sent to the great duke of Tuscany by the Jesuits in China. Dr. William Sherard communicated them to the Royal Society; and to render the accounts useful to the world, he presented them with the several substances mentioned; these are deposited in the museum of the society, and may serve as instructions to all who are curious in this art.

The Chinese have of late years discovered a new kind of varnish for their ware: they call this *tsekinyeou*, that is to say, the brownish gold varnish; it is of the colour of the brown images, or of what we call coffee colour. The novelty of this has made it much esteemed: it is made in the manner of all their other varnishes, by dissolving the finer part of an earthy substance in water.

The substance which they make it of is a common yellow earth: this they dissolve in water, and letting the coarse parts settle, they pour off the yet thick liquor, and what afterwards subsides from this is the pure and fine part, which they keep in form of a soft paste, or thick cream. They use this only to the thinnest and most delicate porcelain ware.

The manner of using it is this: they mix a quantity of this fine sediment with so much water as renders it thin and liquid, like the common varnish: this and the common kind are to be used together, so that care must be taken that they are nicely of the same degree of thickness: this the workmen try by dipping a petunse or brick of their earth into both, and seeing which comes out most covered; that which lies on the thickest is to be diluted with more water, or the other to be heightened with more of the earth, to bring them to the same standard. They are both judged to be sufficiently liquid when they enter the pores of the petunse. They then mix some of the oil of fern ashes and lime along with the brown varnish, and add as much of this mixture to the common varnish as they find upon trial will give such a colour as is required. The common proportion for the brown colour most esteemed at present, is two pints of the brown varnish to eight pints of the common; and to four pints of this mixture they add one pint of the varnish, or oil of fern. It might puzzle a stranger to their terms, to understand what these people meant by oil; but it is a word with them in use for any thing liquid; and they call all their varnishes so, though made of the powders of earths and stones mixed with water. They apply this varnish to the vessels by dipping them into it, and so completely covering them inside and out before they put them into the oven; and the baking gives a great brightness to the colour. This is the nicest part of the whole manufacture of the porcelain, and other wares of that kind.

The varnishes used by the Chinese are two; the one they call *oil of* STONES, the other *oil of* FERN; which see. They mix these together, and with great caution and delicacy apply them to the vessels all over equally, with a steady hand and a fine pencil.

PORCELAIN, *Baking* or *Nealing of*. There are two kinds of ovens used in baking porcelain; large ones, for works that are only used to come to the fire once, which is the common way; and small ones, for such as require a double baking.

The large ones are two Chinese fathoms deep, and almost four wide. They are formed of a mixture of three earths; one of which, yellow and common, makes the basis; the two others are scarcer, and dug out of deep mines, in which people can only work in winter. One of them, called *lautou*, is a very strong stiff earth; the other, *youtou*, oily.

The sides and roof of the ovens are so thick, that one may lay the hand on them, when the fire is at its height, without danger of burning. At the top of the dome, which is in form of a tunnel, is a large aperture, to give vent to the flames and smoke, which mount up incessantly, as soon as fire is once set to the oven: beside the principal aperture, there are four or five small ones around; which, by being opened and shut, serve to augment or diminish the heat; like the holes in the chemists' furnaces, called *registers*. The hearth, which takes up the whole breadth of the oven, is placed in front, precisely against the opening of the door, and is two or three feet deep, and two broad; people passing over it on a plank, to go into the furnace to range the porcelain. As soon as the fire is lighted, the door is walled up, only leaving an aperture for the conveyance of wood. Lastly, the bottom of the oven is covered with sand, in which part of the first porcelain cases are buried. The oven itself is usually placed at the extremity of a long, narrow vestibule, which serves in lieu of bellows; the cold air and wind being thus driven directly in the face of each oven.

Each piece of porcelain of any note, is disposed in the furnace, in its peculiar separate case, or coffin. Indeed, as to tea-dishes, &c. the same case serves for several. The cases are all of the same matter with the oven; they have no lids, but serve each other mutually; the bottom of a second case fitting into the aperture of the first; and thus successively to the top of each column. Each coffin, which is usually of a cylindrical form, that the fire may communicate itself more equably to the porcelains inclosed, has, at bottom, a little lay of very fine sand, covered over with dust of kaolin, that the sand may not stick to the work; and care is taken, that the porcelain may not touch the sides of the case. In the larger cases, which hold the small pieces, they leave the middle vacant, in regard porcelains placed there would want the necessary heat. Each of these little pieces is mounted on a little massive of earth, of the thickness of two crowns, covered with powder of kaolin.

F. d'Entrecolles observes, that the porcelains are put in cases to prevent any diminution of lustre from the too violent effect of a naked fire; adding, that it is owing to those thick veils, that the beauty, or, as he calls it, the complexion of the porcelains, is not tanned by the heat of the fire.

As fast as the cases are filled, a workman ranges them in the cavity of the furnace; forming them into piles, or columns, of which those in the middle are, at least, seven feet high: the two cases at the bottom of each column are left empty, because being partly sunk in the sand, the fire has the less effect on them; and, for the same reason, the uppermost one is left empty. In this manner is the whole cavity of the oven filled with columns, excepting that part precisely under the grand aperture. In ranging the cases, they observe always to place the finest piles of porcelain in the centre, the coarsest at the bottom, and those that are high-coloured, and consist of as much petunse as kaolin, and in which the worst oil is used, at the mouth.

These piles are all placed very near one another, and are bound together at top, at bottom, and in the middle, by pieces of earth, in such manner as that the flame may have a free passage among them, and insinuate equally on all sides; in which a great part of the workman's art lies, and on which the perfection of the porcelain much depends. Another thing to be observed is, that an oven must never be set altogether with new coffins; but half one, half the other: the old ones at the bottoms and tops of the pile, and the new ones in the middle. Indeed it were better to have them all burnt in an oven apart, before they come to

be ufed for porcelain, as was anciently done. The cafes, our author obferves, are brought ready prepared from a large village on the river, a league diftant from King-te-tching. Before they are burnt, they are yellow; and afterwards of a dark red.

When the oven is filled, they wall up the door, only leaving a fmall aperture for the throwing in of little pieces of wood, a foot long, but very flender, to keep up the fire: it is then heated by degrees for the fpace of a day and night; after which, two men, who relieve one another, continue to throw in wood without any intermiffion. To know when the porcelain is baked enough, they open one of the leffer holes of the oven, and with a pair of tongs take off the lid of one of the piles. If the fire appears very brifk and clear, and the piles equally inflamed, and efpecially if the colours of the porcelain, that is uncovered, dart forth a noble luftre, the coction is fufficient; they difcontinue the fire, and wall up what remained of the door of the furnace.

If the oven be only filled with fmall porcelain, they take them out twelve or fifteen hours after the fire is extinct: if it be filled with larger, they defer opening it for two or three days. In this the modern practice differs from the ancient; in which the door was not opened till after ten days for the large pieces, and five for the fmall ones. One thing very furprifing, and almoft inconceivable, F. d'Entrecolles obferves, is, that there are never found any afhes on the hearth of the oven, what quantity of wood foever is confumed. He adds another thing, which with him paffes for equally ftrange, that the workmen employed about the furnaces, flake their thirft by continually drinking hot tea, with falt diffolved in it.

The Chinefe make another kind of porcelain, which they paint and bake twice; and for this fecond baking they have a kind of little ovens on purpofe. Thefe ovens, when very fmall, are made of iron; or otherwife of a kind of bricks an inch thick, a foot high, and half a foot broad, made of the fame earth with the porcelain cafes. The biggeft of thefe ovens do not exceed five feet in height, and three in diameter; and being made much in form of bee-hives, the bricks are arched a little, to form the curvity the better. The hearth is of earth half a foot high, formed of two or three ranges of bricks; and on this maffive is the oven built. Around the oven, at the diftance of about half a foot, is raifed a fhell of common bricks, joined to the oven itfelf by a kind of arcboutant of earth, which ferves to ftrengthen it. They ufually build four or five of thefe ovens at equal diftances from each other. At the bottom of the fhell are holes to give air to the fire when lighted: at top is an aperture, which they cover up with a piece of the baked earth, when the porcelains are laid in the oven.

The porcelains here are not inclofed in coffins, as in the common ovens; the oven itfelf ferving that purpofe, and being fo exactly clofed, that they receive no other impreffion of the fire, but that of the heat of the charcoal difpofed in the hearth, at the bottom of the oven, as well as at top of the vault, and in the interval between the oven and the fhell, or brick-wall.

To prepare the porcelains for a fecond baking, they muft have had their varnifh in the common manner, and have paffed the great oven: in this ftate they are painted with various colours, after which, without giving them any new varnifh, they are ranged in piles in the little oven; fetting the little ones over the larger, in form of pyramids.

The Chinefe are very artful in their difpofition of thefe, arranging them in the moft compact manner, and putting the little ones within the great ones; but great care is alfo neceffary, that the veffels do not touch one another in the parts where they are painted, for the confequence of that would be the fpoiling of both veffels, as the colours would run together. The bottom of one veffel may generally be placed on the bottom of another, though both are painted, becaufe the rims are not painted, and they keep the painted parts from touching one another. High and narrow veffels, fuch as chocolate-cups, and the like, are very troublefome on this occafion. The method the Chinefe workmen take with them, is this: they place a range of them, fo as to cover the whole bottom of the furnace, and they cover this with a thin bed of broken china-ware, over which they place another row of the cups, and fo on to the top, where they lay on no covering; they never bake any thing elfe with thefe cups, when they are of this kind of twice-baked porcelain.

This fecond baking is fometimes intended to preferve the luftre of the colours the better, and at the fame time to give them a kind of relievo; but more ufually its defign is to hide defective places, by covering them over with colours; but the artifice is eafily found out, by paffing the hand over them.

When the workman judges his porcelains enough baked, he takes off the piece that covers the aperture; takes out the charcoal; and, when the oven is cold, the porcelain is fo too.

How beautiful foever the modern porcelain may be, the tafte for antiquity, which reigns in China, as well as in Europe, gives the ancient porcelain a value far above that of the modern.

It muft be owned, the ancient feems finer as to the matter, more perfect as to the baking, and of a more pleafant caft, both as to the white of the ground, and the other colours; yet it is certain, the moft able and difcerning may be deceived in it; and there are workmen who make it their bufinefs to counterfeit the ancient porcelain, called *kutong*, in the modern.

The matter of the falfe kutong is a foft and yellowifh earth, found near King-te-tching. There is nothing particular in the firft part of the procefs, except that they are made thicker, and that they are varnifhed with an oil drawn from the yellow-ftone, mixed with the common oil, which gives them a kind of fea-green hue. When taken out of the oven they throw it into a fatty broth, made of capons, &c., in which they boil it a fecond time; they then bury it in the filthieft fink they can find, for a month or fix weeks, or more, according as they would give it the greater appearance of antiquity. Befides their thicknefs, and their colour, thefe falfe antiques refemble the true ones in this, that they do not refound when ftruck, nor even give the leaft buz when held to the ear.

Notwithftanding the vaft quantity of porcelains made in almoft all the provinces of the empire of China, they ftill continue very dear, though not near fo dear as anciently. The Chinefe annals tell us of times, in which a fingle urn coft ninety or a hundred crowns on the fpot. What chiefly occafions the extraordinary price of this commodity, efpecially in Europe, is, befide the great profits of the merchant in Europe, and their factors in China, that it rarely happens an oven fucceeds throughout; that it is frequently quite fpoiled, fo that upon opening it, in lieu of fine porcelains, is found a hard unformed mafs, into which both the porcelains, and their coffins, are converted, either by excefs of heat, or fome ill qualities in the matter.

Another reafon of the dearnefs of porcelain is, that the ingredients it is made of, and the wood with which it

is burnt, grow more and more fcarce. One may add a third reafon for the exceffive price of porcelains to the Europeans; and it is this: that moft of thofe fent to Europe are formed on new models, frequently very capricious, and difficult to fucceed in; which yet for the fmalleft defects are turned on the manufacturer's hands; and he, not being able to difpofe of them to the Chinefe, becaufe not to their tafte, nor to their ufe, is forced to charge the porcelain he delivers the higher, to pay himfelf for thofe refused.

The art of making porcelain is one of thofe in which Europe has been excelled by oriental nations. However, earthen-wares have been made, for feveral years paft, in different parts of Europe, fo like the oriental, that they have acquired the name of porcelain. The firft European porcelains are faid to have been made in Saxony and in France; and afterwards in England, Germany, and Italy; all of which differed from thofe of Japan and China, but each poffeffing its peculiar character. The firft perfon, who feems to have made this manufacture the object of fcientific attention, was M. Reaumur; and he communicated his refearches in two Memoirs to the Academy of Sciences, in 1727 and 1729. Having broken pieces of the Japanefe, Saxon, and French porcelains, he examined the difference of their grains or internal ftructure. The grain of the Japanefe porcelain appeared to him to be fine, clofe, compact, moderately fmooth, and fomewhat fhining. The grain of the Saxon porcelain was found to be ftill more compact, not granulous, fmooth, and fhining like enamel. And the porcelain of St. Cloud had a grain much lefs clofe and fine than that of Japan, fhining little or not at all, and refembling the grain of fugar. In order to determine their difference ftill farther, he expofed them to a violent heat; and found that the Japanefe porcelain was unaltered by the fire, and all the European porcelains were melted. This effential difference fuggefted to him the moft juft and regular idea, that has yet been formed of the porcelain or china-ware, *viz.* that it is a half vitrified fubftance or manufacture, in a middle ftate between the common baked earthen-ware of our vulgar manufactures, and true glafs. This is the effential and diftinctive character of porcelain; and it is only by confidering it in this light, that we are to hope to arrive at the perfect art of imitating it in Europe.

The determining the due degree of heat for the baking the china-ware, and the finding out the proper time it fhould remain in that heat, are two very effential points in the manufacture of this elegant ware. Perhaps our Englifh attempts to imitate it would be brought nearer the perfection we are aiming at, by a juft regard to thefe particulars, than by many other lefs material articles, about which we feem more folicitous.

This attempt is to be made on thefe principles in two different manners: the one by finding fome appropriated matter on which fire acts with more than ordinary ftrength, in the time of its paffing from the common baken ftate of earthen-ware into that of glafs. The other is to compofe a pafte of two fubftances reduced to powder: the one of which fhall be of force to refift a very violent fire, fo as not to become vitrified in it; and the other, a matter very eafily vitrifiable.

In the firft cafe, the matter is to be taken out of the fire at the time when it is imperfectly vitrified; and in the other, the compound mafs is to remain in the furnace till the one fubftance, which is the more eafily vitrifiable, is truly vitrified; and being then taken out, the whole will be what porcelain is, a fubftance in part vitrified, but not wholly fo.

The firft method is that by which the European porcelain has generally been made; and though that of St. Cloud, and fome other places, has been very beautiful, yet it is always eafy to diftinguifh even the fineft of it from the china-ware, and the nature of the two fubftances appears evidently different; thefe owing all their beauty to their near approach to vitrification, are made to endure a long and violent fire, and are taken from it at a time when a very little longer continuance would have made them perfect glafs: on the contrary, the china-ware being made of a pafte, part of which is made of a fubftance in itfelf fcarcely poffible to be vitrified, bears the fire in a yet much more intenfe degree than ours, and is in no danger of running wholly into glafs from it.

The two fubftances ufed by the Chinefe are well known by the names of *petunfe* and *kaolin;* and on examining thefe, it appears very evident that we have in Europe the very fame fubftances, or at leaft fubftances of the very fame nature, and capable of being wrought into a porcelain equally beautiful and fine. Mem. Acad. Scienc. Par. 1739. See KAOLIN and PETUNSE.

Thefe are the two different femi-vitrifications, on one or other of which all the European manufactures have hitherto been founded; and it is eafy from the knowledge of thefe principles to determine, on breaking a piece of the china of any of our manufacturers, by which of the two proceffes it is made. If it is made by feizing the half-vitrified mafs of a fubftance, which would foon after have been wholly vitrified, then the putting it in a crucible, into an equal degree of fire, will foon turn it wholly into glafs. This is the cafe of moft of our European porcelain; but if it be made of two ingredients, the one of which is not vitrifiable, or at leaft not by fuch fires, then the matter will melt, but will not vitrify. This is the cafe with the Chinefe porcelain, which if kept in fufion a long time, yet when cold is china-ware ftill; fo that this is evidently made of two fuch different ingredients.

Befides thefe methods, there is yet another, of late invention, which makes a very beautiful china; and which, if it does not afford veffels equal to thofe of china, yet will afford them nearly approaching to thofe, and at a confiderably fmaller price. This method confifts in reducing glafs to china. See GLASS-*Porcelain*.

Macquer, the author of the Chemical Dictionary, obferves, that M. Reaumur has erroneoufly confounded the Saxon porcelain with the other fufible porcelains in Europe. For though it contains, as every porcelain does, particularly that of China and Japan, a fufible fubftance, which has been completely fufed in the operation of baking, and to which it owes its denfity and internal luftre; yet it contains alfo a large quantity of a fubftance abfolutely infufible, from which it receives its admirable whitenefs; its firmnefs and folidity, during the baking, fupplying the place of the oriental kaolin, and contracting its dimenfions in a confiderable degree, while it incorporates with the fufible fubftance. He has actually found, that this porcelain cannot be fufed, unlefs by a fire capable alfo of melting the beft Japanefe porcelain. And he obferves, that it is fuperior to the oriental in the fmoothnefs, luftre, and lefs granulous appearance of its internal furface. The manufacture of Saxony has been long eftablifhed; and that at Meiffen, a few miles from Drefden, has produced porcelains painted and enamelled in fuch perfection, that they have been reckoned more beautiful, and fold at a higher price than even thofe of China.

The invention is faid to have been owing to an alchemift called Botticher, who, being confined in the caftle of Konigftein by the king of Poland, on a fufpicion of being

master of the philosopher's stone, had leisure sufficient, not indeed to make gold, but to invent a ware, which, by the excellence and value of it, considerably enriches the country. He died in 1719, but it seems that he only invented the white sort; the art of making brown and blue porcelain not having been discovered till the year 1722.

Porcelain is also made at Vienna, Frankendal, and lately in the neighbourhood of Berlin; all which are made of the same kind of materials with those of Saxony. In Italy there are also manufactures of porcelain, at Naples, and Florence. In France they have had manufactures of this kind for many years: porcelain was made at St. Cloud, and in the suburb of St. Antoine at Paris, before M. de Reaumur's publication; but though beautiful, it was of the vitreous and fusible kind. Since that time, considerable manufactures of it have been established at Chantilly, Villeroi, and Orleans, the porcelains of which have a distinguished merit; but those produced in the king's manufactory at Seve are said to do greatest honour to France, on account of their shining, white, beautiful glazing, and coloured grounds.

M. Guettard, who has published an account of his discoveries in the Memoirs of the Academy of Sciences for the year 1765, seems to have been one of the first who, since M. Reaumur, found in France a kaolin and petunse of the same nature as the Chinese: the former is a white argillaceous earth filled with mica; the latter a hard quartose stone. The count de Lauraguais has also so far succeeded in his attempts in this way, that some pieces, presented by him in 1766 to the Academy of Sciences, were declared to resemble the porcelain of China and Japan in solidity, grain, and infusibility, more than any other that had been made in that country, though it wants the whiteness and lustre observable in the ancient Japanese porcelain.

In the first attempt to make porcelain in France and in this country, it possessed very inferior qualities to that made in China and at Dresden: it was much more fusible, and had an open fracture. In consequence of these defects, it has been distinguished from genuine porcelain by the name of soft and tender porcelain.

It is painful to confess that we have not as yet produced any thing superior to the latter in this country. The French, till the discoveries of Reaumur and others, did not make the real porcelain.

Porcelain appears to have been first brought into Europe by the Portuguese, but at what period it is difficult to say; but doubtless long before any attempts were made by the Europeans to manufacture it.

The first attempt was, as we have already observed, by baron de Botticher, a German chemist. In making some crucibles, he found they assumed by heat the character of porcelain. This gave rise to the manufactory, which is still carried on at Dresden; and it is curious to have to remark, that their materials, from the first, proved to be similar to those employed in China.

The success of this manufactory soon produced other attempts in France and this country. It was known that the Chinese employed two substances for the body of the porcelain: one called kaolin, having the ductile properties of clay; and the other named petunse, which was a white stone, and did not produce a paste in itself.

A French missionary in China, of the name of d'Entrecolles, sent over to France specimens of the kaolin and petunse, with such instructions as he could collect. It seems that very little was gained by this. They did not at first succeed in finding similar materials in France; and if they had, the account given them by d'Entrecolles was so defective, that it rather misled them than otherwise. Very little progress was made by the French, till the celebrated Reaumur, as we have already mentioned, investigated the subject. His first object was to examine the fracture of the different porcelains. He found the fracture of Chinese porcelain to be very compact, but slightly granular; the Dresden more compact, and resembling enamel; that of St. Cloud, which was the best attempt after the Dresden, had an open granular fracture, more resembling sugar. His next object was to ascertain their relative degrees of fusibility. He found the Chinese to withstand the greatest heat without fusion, while the others yielded to the ordinary heat of furnaces. He concluded from his experiments, that it was essential to have two substances for the formation of porcelain. The one should constitute the body or skeleton of the substance, by being infusible with the greatest heat of the furnace employed; the other substance should, at the greatest heat required, become fused, and enveloping the infusible parts, constitute the semi-transparency so conspicuous in porcelain. The first of these properties he found to exist in the kaolin, and the second in the petunse of the Chinese.

It was not, however, till after the researches of Macquer and Montigny, that the French porcelain became fit to compare with that of Dresden and the Chinese. They put the manufactory at Seve in possession of the means of employing substances similar to kaolin and petunse, with as much success as the Chinese.

If, agreeably to the principle laid down by Reaumur, porcelain is constituted of two substances, one of which is infusible, and acts as a prop or skeleton, while the other, which is fusible, cements and binds the infusible parts together; it will be easy to conceive, that a great variety of this species of earthen-ware may be formed with substances possessing different degrees of fusibility. The best and true porcelain, however, appears to be formed when the fusible part of the porcelain requires the greatest heat for that purpose. This is the petunse of the Chinese, and is similar, if not the same, with the feldspar which is found in Cornwall, and employed in most of the manufactures here. The other substance to which the porcelain mass owes its ductility, is called porcelain clay, and by some porcelain earth. This is nearly the same with the kaolin of the Chinese. Sometimes the substance known by the name of soap rock, and also called steatite, is employed with the kaolin, or porcelain clay. This is said to give firmness to the infusible part of the porcelain. A substance similar to this last is in some cases used by the Chinese. The body of the best porcelain should, therefore, be formed of certain proportions of porcelain clay with the feldspar. The less of the latter, the more difficult it will be to bring about the semi-transparency by heat. But if the feldspar were in great proportion, the vessels so formed would shrink in the fire, before the diaphanous property was produced. If vessels were made solely of the porcelain clay, without any feldspar, they would possess great whiteness and firmness, but not the least transparency. Hence this clay answers very well for crucibles or other vessels required to resist great degrees of heat. Porcelain made of the best proportions of these two substances, we have before observed, is called hard porcelain. In some parts of France, and in this country, the porcelain is made of these substances in part, but other materials are employed to give the required transparency at a lower temperature. This has received the name of soft porcelain. The receipts for making soft porcelain are very numerous; scarcely two manufacturers using the same, although each keeps his own a profound secret, and thinks it the best.

They all ufe more or lefs of porcelain clay and feldfpar. The former is often called Cornwall clay, the latter Cornwall ftone. This they employ in different proportions with bone afhes. The latter conftitute the infufible part, while the feldfpar, which is ufed in greater proportion, fufes to give the tranfparency. Some ufe gypfum in their compofition, to give it an opal appearance. All thefe porcelains are fo fufible, that they are obliged to be glazed with a fubftance containing oxyd of lead, which muft ever be confidered as objectionable in the manufacture of veffels ufed in domeftic life. The true porcelain is glazed with feldfpar, which can only be effected when the fabric will bear a heat fufficient to make the coating of feldfpar flow thinly over the furface.

It may be proper here to ftate fome facts refpecting the porcelain clay and the feldfpar, which may be a means of improving upon the materials which nature furnifhes.

The Cornwall ftone is a fpecies of granite in a ftate of decompofition, and principally confifts of feldfpar. The porcelain clay is found in fituations where this decompofition is conftantly going on, and the clay is feparated by the action of water, which wafhes thefe parts mifcible with that fluid into pits made, in fucceffion, for the purpofe. In order to give fome idea of the fimilarity between feldfpar and porcelain clay, we will give the following analyfis by Vauquelin.

Feldfpar.	62.83	Silex
	17.02	Alumine
	3	Lime
	1	Oxyd of iron
	13	Potafh
	96.85	
Porcelain clay.	55	Silex
	27	Alumine
	.5	Oxyd of iron
	14	Water
	2	Lime
	98 5	

Before it was fufpected that the alkalies entered into the compofition of minerals, the analyfis of thefe two fubftances afforded nearly the fame fubftances, offering very little in their proportions. In the analyfis of feldfpar, however, a great lofs was always obferved, which could not be accounted for, but which is now found to be potafh. This fatisfactorily explains the fact of porcelain clay, from which the alkali has been feparated by the decompofition of the feldfpar, being infufible with the greateft heat of furnaces; while the feldfpar itfelf, which contains potafh, melts at little more than a red heat. Thefe facts will, no doubt, give fome valuable hints to the fcientific manufacturers of porcelain.

It may feem to the reader a little ftrange, why the foft porcelain, which is a vague and artificial compofition, fhould be made at all, and why the fimpleft proportions of the clay and Cornwall ftone fhould not be univerfally employed. In anfwer to this we may ftate, that in none of the manufacturing arts in which fire is an important agent, has there been lefs fkill difplayed, or lefs improvement made, than in the potter's kiln, which from its conftruction is limited to a very low degree of heat, and has befides many other defects, which muft ever be an obftacle to the manufacture of porcelain. On this fubject we fhall give fome obfervations in another place. We fhall now proceed to go through the different manipulations for many veffels of porcelain, which will be the fame whatever may be the nature of the materials.

Previoufly to the different materials being mixed which are to conftitute the mafs from which the veffels are to be formed, they are firft ground between two furfaces of chertz or porphyry: the firft of thefe is a hard filiceous ftone, found in Derbyfhire, and other places. The paffive part of this machine confifts of thefe ftones, which occupy the bottom of a cylinder, about twelve or eighteen inches in depth, and from fix to ten feet in diameter. In the middle of the cylinder works an upright fhaft, with arms at right angles, on which are placed the active ftones, fo that by the rotation of the latter upon the paffive ftones, the fubftance, fuch as flint or feldfpar, is ground. As much water is always prefent as keeps the fubftance grinding to the confiftency of pulp.

After the fubftances have been ground in this way to a certain finenefs, which alfo effects their intimate mixture, the pulp is paffed through a fieve of fine filk. The operation is called *lawning*. This renders the pulp very fine, and prepares it for evaporation.

The evaporation of the water is performed in a veffel made of fire-brick; its furface is great, and the depth not more than twelve to eighteen inches. The breadth is about fix feet. The fire is at one end, and the flame runs under the whole length, to the chimney at the other end. The heat is given very flowly to the pulp, till the mafs will admit of being cut out with a fpade in fquare maffes. Thefe maffes are a little too foft for working, and require another operation, called wedging or flapping. This confifts in feparating each of thefe fquares with the hand, and flapping them violently together on different fides to thofe immediately feparated. This is repeated till the mafs becomes perfectly uniform. In mixing water with clay or any other dry fubftance which requires to be thoroughly penetrated by that fluid, it is found that confiderable time is neceffary to do it effectually for this purpofe. It is common, after the firft wedging, to allow the mafs to remain undifturbed for fome time. This allows every part of the fubftance to be faturated with water, and the mafs requires that degree of uniformity and tenacity, by which it is worked with greater facility. Previoufly to being worked it undergoes another wedging, by which it acquires the proper confiftency for working into utenfils of different kinds.

This branch of the art is divided into three departments, namely, throwing, preffing, and cafting.

Throwing is performed upon a machine called the potter's lathe. This confifts of an upright fhaft, about the height of a common table, on the top of which is fixed a circular piece of wood, of a breadth fufficient for the wideft veffel to ftand upon. The bottom of the fhaft runs in a ftep, and the upper part in a focket a little below the circular board, fo that the fhaft and the board turn together. The fhaft is turned by a pulley, placed upon it by a band, which paffes from it to a wheel about ten times the diameter at fome diftance. This latter, being turned by a handle, gives motion to the lathe. The maffes to be thrown are firft weighed out. The thrower places the mafs on the face of the circular board, which is in motion, and fhapes it by his hand and fingers previoufly wet, aided by the circular motion, to the defired form. He then cuts it off at the bafe by means of a piece of fine brafs wire, with a handle at each end. The veffels thus roughly formed are placed in a fituation, where they dry gradually to a certain extent. During the drying of the veffels, there is one point in which the clay poffeffes a greater tenacity and hardnefs than at any

other period. This is called the green ſtate. At this period they are taken to another lathe, which, to diſtinguiſh it from the throwing lathe, is called a turning lathe. The veſſel is here ſlightly attached to a wooden chock by wetting, and then turned into its proper ſhape with a very ſharp tool, which gives it great ſmoothneſs at the ſame time. After this it is ſlightly burniſhed with a ſmooth ſteel ſurface. Such veſſels as require to have other parts attached to them, ſuch as handles, ſpouts, &c. undergo this operation when they come from the turning, this being the proper ſtate of dryneſs for that purpoſe. The handles are firſt made of the proper ſize and ſhape in moulds of plaſter: they are then ſtuck to the veſſels, by means of a pulpy maſs of the ſame material, of the conſiſtency of thick cream. In this ſtate it is called ſlip. The ſurface where the union is formed is then ſmoothed with a wet ſponge. The veſſels are now taken to the ſtove to be thoroughly dried.

When they are perfectly dry they are examined, to ſee if any parts be ſtill rough; indeed, ſome places cannot be made perfect in the green ſtate. The perfect finiſh is given by rubbing the rough parts with a ſmall bundle of hemp.

The throwing and turning can be employed only for ſuch utenſils as are of a circular form. When the form is otherwiſe, recourſe is had to moulds. The moulds are made of plaſter, and ſometimes, for delicate work, of ſulphur. The clay is firſt made into a flat piece of the thickneſs of the veſſel: it is then gently preſſed into one-half of the mould, a ſimilar piece being preſſed into the other half. The two halves are now united together, and the plaſter moulds removed. The veſſels now undergo repairs, and are ſet to dry, to the ſame degree at which the thrown articles are turned. The veſſels are now all finiſhed as to their form and the different appendages, which are put to them by means of the ſlip. Theſe are now fully dried, and finiſhed by rubbing with hemp.

The caſting operation conſiſts in pouring the clay, in the ſtate of pulp or ſlip, into plaſter moulds, which are kept in a certain ſtate of dryneſs. Theſe moulds are made in two halves, and fit together in the ſame way with thoſe uſed for caſting metals: the pulp is poured in till the cavity is quite full, and ſuffered to remain for a certain time, which is more or leſs according to the intended thickneſs of the veſſel: that part of the pulp which is contiguous with the plate ſoon loſes its exceſs of water, which is abſorbed, leaving the clay in that part ſo ſtiff, that when the unchanged pulp is poured back, a portion remains, which, when removed from the mould, conſtitutes a veſſel, the exterior of which has the exact form of the mould; the thickneſs of the clay being more or leſs, according to the time the pulp remains in the mould.

The articles formed in this way are dried to the green ſtate, ſimilar to thoſe above-mentioned, at which period the parts to be united are put together with ſlip.

It is in this way that the greater parts of thoſe elegant figures and ornamental works are formed, and ſold in a ſtate of white biſcuit. Theſe are made in the greateſt perfection at the Derby porcelain works. The imitation of flowers and foliage is exquiſitely managed. Each of the leaves and petals being made in a ſeparate mould, renders this kind of work very expenſive.

All the various kinds of work made by the different proceſſes, after being finiſhed, ſo far as regards their ſhape, are placed on a ſtove to keep them in a hot ſtate for burning, till there is a ſufficient quantity to fill the kiln.

The next proceſs is that of burning or firing, which conſiſts in giving the porcelain a very conſiderably red or almoſt white heat, by which it acquires its hardneſs, and poſſeſſes at the ſame time great whiteneſs, and is ſemi-tranſparent. In this ſtate it appears like very white ſugar, and it is called biſcuit.

The potter's kiln, which that uſed for porcelain ſtrictly reſembles, is built in the form of an erect cone, with an opening at the top for the eſcape of ſmoke. A certain part within the cone is built with fire-bricks, within which the veſſels containing the porcelain are piled one upon another. Theſe veſſels for defending the ware from the immediate action of the fire, are called *ſaggars*, which in all probability is a word corrupted from *ſafeguards*. They are cylindrical veſſels from twelve to eighteen inches in diameter, from ſix to twelve inches deep, and from one inch to one and a quarter thick. Theſe dimenſions, however, vary with the ſize of the articles to be burnt.

The bottoms of the ſaggars are ſlightly covered with a fine white ſand, which does not change by the fire. The particles act like ſo many little ſpheres, allowing the porcelain to touch the ſaggar's bottom only in a few points.

When the ware is put into the ſaggars, they are to be piled up in the kiln, each ſuperior ſaggar ſerving as a lid to the one beneath it. Theſe piles are by the workmen called *bungs*. Before one ſaggar is laid upon another, a ring of ſoft clay is laid upon the edge of the lower one; ſo that the upper one, being placed upon it, ſecures the ware in the ſame from any duſt or ſmoke. The rings of clay ſo placed between the ſaggars, are called *wads*. The uppermoſt ſaggar is, laſtly, covered by a lid, or an empty additional ſaggar.

The piles in the kiln being completed, the next thing is to apply the fire. This is made with wood on the continent, and probably in China; but in this country the kilns are fired with pit-coal, that producing the moſt flame being preferred for this purpoſe.

The fire-places are generally ſeveral in number, more or leſs, according to the ſize of the kiln. They are made at the bottom of the cone, on the outſide, and the flame penetrates the kiln through a horizontal flue, and then aſcends perpendicularly, ſurrounding the piles of the ſaggars, till it makes its exit at the opening in the top of the cone. The want of a ſufficient quantity of oxygen in the body of the kiln does not afford a perfect combuſtion of the ſmoke. This not only limits the heat which is ſo eſſential, but is the cauſe of immenſe volumes of unburnt matter eſcaping from the chimney, to the annoyance of the ſurrounding country. (See the kiln deſcribed under POTTERY.) The fire is kept up from twenty-four to forty-eight hours, when the kiln is ſuffered to cool before the ſaggars are diſturbed.

The porcelain is now taken from the ſaggars, and cleared from any particles of ſand which may have adhered to it. In this ſtate it is called biſcuit. All the common earthen-ware and the ſoft porcelain are ſo porous in the ſtate of biſcuit, as to be permeable to water, and, in conſequence, would be uſeleſs, without the ſurface being covered with glaze, in order to fill up the pores.

The glazes uſed for ſoft porcelain, and the common earthen-ware, are mixtures of ſome earthy ſubſtance, ſuch as flint or clay, or both combined, with ſome vitrifiable metallic oxyd, in order to give it the neceſſary fuſibility. The oxyd of lead is generally employed for this purpoſe, with ſometimes the addition of oxyd of tin or arſenic, in order to give the glaze a certain degree of opacity. In the hard porcelain, ſuch as that of China and Dreſden, the glaze does not contain lead or other metallic oxyd, except we call potaſh the oxyd of a metal. The porcelain being formed of ſuch proportions of the porcelain clay and the feldſpar, as to bear a great degree of heat, a glaze may be employed, much

lefs fufible than thofe employed for the foft porcelain. The glaze of fuch porcelain is, therefore, the feldfpar alone. We have before ftated, that the feldfpar owes its fufibility to a certain portion of potafh which it contains: it might hence be inferred, that the common fufible glaze could be formed by combining potafh or foda with earthy fubftances, in greater proportions, and thus obviate the ufe of oxyd of lead entirely, which, from its poifonous qualities, is very objectionable. Such an expedient has often, and is ftill reforted to, by the manufacturers of earthen-ware; but it is found, that when a glaze contains more than a certain proportion of alkali, it does not undergo the changes of expanfion agreeably with the body on which it is laid, and is apt, in confequence, to crack. It is not uncommon to fee fome of the very common fpecies of earthen-ware appear covered with cracks on the furface. Whenever this happens, the body foon becomes penetrated by greafe, or any other fubftance applied to the veffels fo glazed. The oxyd of lead, in a certain proportion, forms a more permanent glaze, and is lefs liable to the above objection; but we find that acids, particularly vinegar, diffolve the lead in fuch glaze, and has, in many inftances, been productive of bad confequences. The glazing ufed for the foft porcelain in general contains lead, and differs very little from that ufed for common white earthen-ware, which is generally called white enamel. Since the fubftance known by this name enters into the compofition of the porcelain glaze, and alfo into the flux ufed as a vehicle for the colours, we will give the procefs for forming white enamel, as recommended by Chaptal in his Chemiftry applied to the Arts. Take equal parts of lead and tin, and expofe them on a melted flate till they are completely oxydated. Let the powder fo formed be ground with water, and well wafhed from any impurities, which will be known by the water being clear. This fine powder being dried, is kept free from duft. This being done, take the whiteft flints, and fufe them with falt of tartar, or carbonat of potafh; the latter being in fuch proportion to the flint, that the compound may be foluble in water. If to the folution of flint fo formed, muriatic acid be added till flint ceafes to be precipitated, the precipitate may be confidered as pure filex. This being well wafhed and dried, is kept for ufe. Of the firft preparation of tin and lead, take 100 parts; of the prepared flint, 100 parts; to thefe add 200 parts of carbonat of potafh: fufe the whole in a clean white crucible, and pour it on a clean flate: when cold, reduce it to a fine powder, and keep it for ufe.

This preparation is intended for the niceft purpofes. For the common earthen-ware lefs pains would be taken in preparing the flint and the oxyds of lead and tin. In future this preparation will be called white enamel. If the porcelain to be glazed will not bear a great heat, the white enamel may be ufed alone as glazing. The three following are recommended by count Milly in his work on porcelain. Firft, very white quartz, 8; white enamel, 15; and calcined gypfum, 9. The fecond is, 17 of quartz; 16 of white enamel; and 7 of gypfum. The third is, 11 of quartz; 18 of enamel; and 12 of gypfum.

Thefe poffefs different degrees of fufibility, according to the lead they contain. The very hard porcelain, fuch as that of Drefden or China, is glazed with feldfpar alone: for this purpofe, the feldfpar is reduced to a fine powder, fimilar to that conftituting the glaze already mentioned.

Having now pointed out the material for glazing, we will fhew the manner of laying it upon the bifcuit, in which ftate we left it when taken from the kiln, and cleared from any fmall particles adhering to it. The material for glazing is to be mixed with water till it is about the confiftence of frefh cream. The powder fhould be extremely fine, that it may remain in fufpenfion. The mixture, befides this, fhould be agitated all the time of glazing, in order to keep the fluid of an uniform thicknefs. The bifcuit is dipped into the glaze. On taking it out, the piece of porcelain is to be turned haftily into different pofitions, in order that the covering may be uniform. The bifcuit, from its porofity, abforbs the water from the folid part, leaving a coating which is of fufficient hardnefs to remain permanent till it is expofed to the fire. Thofe articles which are coloured in any part with cobalt, and fometimes the black or brown colours, require to be painted with the colouring matter before they are dipped in the glaze. In thefe inftances the colours are feen to the greateft advantage through the glazing.

The next procefs is the firing. To fufe the glaze for this purpofe, the coated ware is placed in clean faggars, fuch as thofe ufed in the firft firing. That part of the porcelain which is to reft upon the bottom of the faggar has the glazing rubbed off. If this were not the cafe, the glaze would faften it to the bottom of the faggar. The faggars are now to be piled up in the fame kiln, and in the fame manner as employed in the firft firing, but the temperature not fo high: it fhould be, however, juft fufficient to give perfect fufion to the glaze. The heat employed for the feldfpar glaze, in the manufacture of hard porcelain, is much greater than for the glaze of the foft kind, although the relative degrees of the bifcuiting and glazing heat may be nearly the fame in each kind. In this ftate the porcelain has attained all its ufeful qualities, the painting and gilding requiring an additional procefs. Before we fpeak of the method of laying on the colour, we fhall give fome account of the preparation of the colouring materials, and the proper flux by which the colour is united to the body. The different colours are produced by metallic oxyds: thefe bodies are, in general, capable of affuming a vitreous form with different degrees of facility. The oxyd requires to be accompanied by a certain vehicle, called a flux, which has the effect of rendering the whole more fufible than the firft or proper glazing already defcribed. Some manufacturers exclude lead from their flux ufed with the colour, as being injurious to the colour; others employ it conftantly. Certain it is, however, that in its tendency to promote the fufion of the under glaze, the colour becomes diluted, particularly when too much heat is employed.

The flux which contains lead may be formed by adding a little borax to the white enamel already defcribed, fufing the mixture, and reducing it, when cold, to powder.

The flux given by Chaptal for this purpofe confifts of glafs in powder, free from lead, 20 parts; calcined borax 11 parts; and purified nitre 22.

The flux, whatever may be its compofition, is to be ground with fome metallic oxyd into fine powder. It is then mixed with oil of lavender, or, what is cheaper and better, old oil of turpentine. The latter is merely to give that confiftency to the whole, which will make it, in the beft ftate, to be laid on the work with a camel's hair pencil.

As the preparation of the metallic oxyds to be ufed as colouring matter, require great nicety in their preparation, we will give fome account of the beft means of their preparation, before we proceed to ftate the different proceffes of painting porcelain.

Colour produced by Gold—The oxyd of gold has been confidered a valuable fubftance in producing the carmine, rofe, and purple tints. The moft common preparation is the purple powder of Caffius: it is prepared by diffolving the

gold in aqua regia, formed of equal parts of nitric and muriatic acids. Next diffolve tin in the fame menftruum, keeping the veffel in which the folution is formed as cool as poffible. The folutions of each fhould be perfectly clear. Firft dilute the folution of gold with three or four times its bulk of water; then add the folution of tin by a very little at a time: a purple precipitate will fall down. Continue to add fmall portions of the folution of tin till no more purple precipitate is produced. It muft be obferved, that the folution of tin fhould be kept clofe ftopped from the air, between the intervals of ufing it; as the prefence of oxygen would foon render it unfit for forming the purple powder. This powder is well wafhed by pouring hot water upon it, and drawing off the clear liquor from time to time. It is then to be dried and kept for ufe. The yellow oxyd of gold is fometimes ufed for painting. It is obtained by precipitating it from its folution by an alkali, or by lime water. The precipitate is to be wafhed and dried in the fame way as the laft, and kept for ufe.

When either of thefe fubftances is ufed, they are to be intimately ground with the flux above-mentioned, in quantity proportionate to the intenfity of the colour required. The mixture is then ufed by fome manufacturers in that ftate for painting. Others fufe the mixture into a glafs, and again reduce it to powder. In either ftate it is mixed with oil of turpentine till the mixture affumes a proper ftate for the pencil. The figures are painted upon the glazed porcelain, the volatile part evaporates, leaving the colouring matter with a fmall remain of refinous. In this ftate the goods are ready for a third firing, to fix and bring out the colour by the fufion of the vitreous colouring matter. When the fufibility of flux is greater than common, and the heat moderate, the purple colour is produced; the rofe colour requiring lefs flux and more heat.

The purple colour is alfo produced by the addition of a little more lead to the flux than is ufed for carmine and rofe colour.

The carmine colour is alfo produced by means of oxyd of gold, produced by the flow decompofition of fulminating gold, and a fmall portion of leaf filver, or muriat of filver. The preparations of gold are chiefly confined to the manufacture of what is called tender or foft porcelain, for producing carmine, purple, and rofe colours. When employed for the hard porcelain, fuch as that of Drefden and the French, the colours are very apt to change, from the great heat employed to bake them, and in confequence they have almoft entirely ceafed to be ufed in thofe manufactories.

Iron Colours.—Iron is capable of producing a variety of colours on porcelain, but it is the moft celebrated for producing red and rofe colour. For the latter colours it is ufed in the ftate of pure oxyd, which fhould be of the fame colour before and after baking. It is commonly prepared for the common pottery by calcining green vitriol at a red heat, in which ftate it is called *colcothar* and *crocus martis*.

For the delicate colours of porcelain, it is common to prepare it with nitric acid. For this purpofe, diffolve the pureft iron in ftrong nitric acid. This acid oxydates the iron to its maximum. Let the folution be diluted, and ftand till it is perfectly clear; then add a folution of carbonat of potafh, till the whole of the oxyd of iron is precipitated. Wafh the precipitate well with hot water. Drive off the laft wafhing by heat, and raife the heat almoft to rednefs: this will drive off the carbonic acid. This oxyd will now be of a fine red colour, and is fit for ufe. A certain portion is now mixed, and intimately ground with the flux, which is then laid on with the oil of turpentine, fimilar to the gold colour.

This colour is employed with great fuccefs in painting hard porcelain for the rofe and red colours, and is much preferred to gold. On the contrary, the iron colour does not anfwer fo well for the foft porcelain, as it becomes very faint by baking, and fometimes almoft difappears when the heat is great. It may appear a paradox that the iron fhould anfwer for hard porcelain, which is baked at a much greater heat than the foft; while it fhould totally fail with the foft, if the heat be much increafed above its common heat. This fact is explained, by attributing the faintnefs of the colour to the foftnefs of the under-glaze of the foft porcelain, which abforbs the colouring matter; while the hard and lefs fufible glaze of the hard porcelain, which is moftly feldfpar, has no fuch effect upon the colour. The oxyd of lead, which is generally prefent in the flux, may alfo have a tendency to leffen the intenfity of the colour of the iron.

Oxyd of lead, as a colour, is generally ufed in the ftate of minium (red oxyd of lead) and litharge. It is reduced to a very fine powder, and wafhed very clean. It is often ufed with oxyd of tin and flint, and fometimes potafh. Its general effect, when in fufficient quantity, is to produce a yellow colour. The lead, being in fmall quantity, and mixed with a certain portion of oxyd of manganefe, has no colour. The oxyd of lead alone fufes into a tranfparent glafs of a beautiful yellow colour.

Oxyd of antimony is employed to give a yellow colour to porcelain. The oxyd is prepared by diffolving antimony in the ftate of regulus in muriatic acid, with heat, and to the clear folution add water, till no more precipitation takes place. Separate the white powder, and add to it a folution of carbonat of potafh to take up the remaining acid. The white powder, well wafhed with hot water, and dried, will be the pure oxyd of antimony. This oxyd may be fufed into a yellowifh vitreous mafs. If it be expofed to heat for fome time, it abforbs more oxygen from the atmofphere, and becomes volatile. This oxyd, with its proper flux, which may be fimilar to that ufed for the other oxyds, produces a yellow colour. It is generally ufed with lead, and fometimes alfo tin for this colour.

Oxyd of cobalt is almoft the only fubftance ufed for giving a blue colour. Its being ufed with fo much certainty, as well as its fuperb colour, renders it of great importance in manufactures of porcelain and pottery. To prepare oxyd of cobalt, let the arfenical ore of pyrites be treated with nitric acid. Moft of the fulphur is feparated in its pure form, but fome becomes converted into fulphuric acid. The latter, with the arfenic acid, formed at the expence of the nitric acid, is to be feparated by the nitrat of lead, adding the latter fo long as any precipitate is formed, but not more. If an excefs has been added, the lead may be feparated by fulphuric acid. If copper be prefent, feparate it by a bar of iron. Precipitate the oxyd of cobalt, held in folution by carbonat of potafh. If the precipitate be digefted in liquid ammonia, the oxyd of cobalt and nickel, if any, will diffolve, while the others will remain. Drive off the ammonia, and add a folution of pure potafh: the pure oxyd of cobalt will diffolve, leaving the nickel behind. The pure oxyd may be feparated by adding an acid. This laft procefs is to be purfued only when it is required to get the oxyd in a ftate of purity. The common procefs is to roaft the ore above-mentioned, by which the arfenic and fulphur are expelled. The refiduum confifts of the oxyd, contaminated with a little iron, nickel, and copper, and with filex. In this ftate it is fold under the name of *zaffer*. This mafs admits of fufion into a blue vitreous mafs, which is called *fmalt*. In the two latter ftates it is ufed in the colouring of common pottery. We have already obferved that oxyd of cobalt, when ufed for the blue colour, is in general

laid on before the glazing. This is more particularly the cafe when the deep blue ground in porcelain is to be formed. The greater the heat, the more intenfe and fine this colour becomes. Hence the blue is much better upon hard than foft porcelain. When great heat is given to it, the oxyd becomes, in fome meafure, volatile, fince the white ground in its vicinity becomes a little tinged with its colour. The oxyd of copper has hitherto been employed for producing a green colour. There are two oxyds of this metal, one the brown or protoxyd, the other the black, containing a maximum of oxygen. The former produces a reddifh-brown, the latter the green colour. The brown oxyd is generally obtained from the furface of copper by the action of heat. The brown fcales which are detached from the furface are made into a fine powder. The black oxyd is beft obtained by firft precipitating the oxyd from a nitric folution of copper by lime water. Let the precipitate be diffolved in ammonia; then draw off the ammonia by diftillation, and the black oxyd will be left in the refiduum.

The brown oxyd, being melted with its flux, produces a reddifh-brown glafs. This, being pounded, may be ufed with other colours for producing the different tints of red and brown. The black oxyd, treated in the fame way, produces a green colour. The oxyd of nickel has been tried in painting on enamel and porcelain, and is faid to produce a green colour. The oxyd is obtained from the ore by the fame method given for obtaining oxyd of cobalt. The ammoniacal folution fpoken of in that procefs, generally contains both thofe metals. The refiduum which the folution of potafh leaves, is oxyd of nickel.

The oxyd of chrome has been tried in the manufactory at Seve by Brougniart. With the chromat of lead he produced a blue of confiderable beauty. This fubftance is found in nature, and might be employed to advantage.

The oxyds of tin and arfenic do not produce any colours, but have the property of producing opacity when united with tranfparent vitreous bodies. The former, it may be remembered, is in the compofition of the white enamel before-mentioned, to which it owes its milky and opal appearance. Arfenic has the fame property to a certain extent. The latter, however, may be united with glafs, without diminifhing its tranfparency. The mafs, when fufed, becomes tranfparent; but when it is expofed at a red heat to the air for fome time, it affumes an opaque and opal appearance. Arfenic is very feldom ufed in enamels, the oxyd of tin anfwering the fame purpofe: this circumftance, and alfo the danger in preparing arfenic, are fufficient reafons for laying it afide. With thefe metallic oxyds, feparately or combined, all the varieties of tints which can be produced in the common methods of painting are obtained.

Thefe may be divided into blue, purple, violet, red, rofe colour, carmine, brown, orange, and yellow.

The blue is produced to the greateft advantage by the oxyd of cobalt. Its flux for foft porcelains is potafh, filex, and lead; that for hard porcelain being feldfpar alone. The flux recommended by Chaptal, already given, would anfwer for the foft porcelain. In fome inftances it might be proper to ufe lead inftead of borax. When lead is ufed, the coloured coating is lefs liable to crack and peel off. When borax or potafh is ufed in fufficient quantity, the lead may be omitted.

The purple is produced on foft porcelain by the purple powder of Caffius, the flux containing a greater proportion of lead, in the abfence of which the colour would incline to red. Oxyd of manganefe, which is found plentifully in nature, and ufed for bleaching, produces a purple colour, but it is feldom ufed for that purpofe. The purple tint may alfo be produced by the mixture of red oxyd of iron with cobalt. Thefe may alfo give the different ftates of indigo and violet.

The reds are produced in foft porcelain by a compound of one part of the purple powder of Caffius, and five or fix of the flux with borax. This red, with particular management, may be varied from a carmine to the rofe colour. Thefe colours may be much modified by the ufe of a little leaf filver, or muriat of filver ground up with the flux. The reds of hard porcelain are produced with good effect from the red oxyd of iron. If this oxyd be mixed with an oxyd of the fame metal having lefs oxygen, a great variety of tints may be produced from orange and carmine to purple. Indeed it may be poffible to produce every poffible colour with iron in different degrees of oxydation. Manganefe may be employed with iron to afford a variety of tints.

Browns are produced in foft porcelain by the brown oxyd of copper, with manganefe and the brown oxyd of iron. By varying the proportions of thefe, different fhades of brown are obtained.

Orange and yellow are produced by the oxyds of lead and antimony, and different proportions of red oxyd of iron give various tints of orange. The antimony and lead produce yellows of different degrees of intenfity, according to the quantity employed. Great care is required in the management of the heat; if the heat be too great, the oxygen leaves the lead and forms black fpots.

In all inftances the colour is to be mixed with the flux, and fometimes fufed with it, and afterwards reduced to powder. This is more efpecially the cafe when oxyd of copper is employed. The powder is ground with oil of turpentine rather in a vifcid ftate: with this fubftance the articles are painted. After painting they require to be baked or fired, for the purpofe of fufing the matter laid on. This is not only neceffary to fix it, but in moft inftances the colour does not appear till it becomes fufed with its flux. The baking is performed in furnaces, called enamel kilns. The enameller, who has the fame work to perform, ufes a muffle. But in baking porcelain the furnace employed is generally made of caft iron. It confifts of a cubical veffel provided with a lid: four fides are furrounded by a loofe wall of brick, perforated with holes. The fpace between the two veffels is about four or five inches: this cavity is filled with charcoal. The outer cafing is deeper than the inner, that the top may be covered with charcoal. The holes in the outer cafing are to admit air for the combuftion of the charcoal.

The ware is piled up in the enamel kiln on iron grates, refting on earthen props of different lengths, forming alternate ftrata with the grates, and the lid placed upon it. The charcoal is now fet on fire at the top, and kept up till the colour is brought out. For the purpofe of afcertaining when the proper effect is produced, there is an opening from the fide by a tube which paffes from the outer cafing to the inner veffel. Small fpecimens are paffed through this tube, having the different colours painted upon them. The tube is ftopped with a plug. Thefe fpecimens are withdrawn from time to time with a pair of fmall tongs, in order to know when the fire is to be removed. The whole is now left to cool before the porcelain is taken out.

It will be obvious, that when one colour requires to be laid upon another, this is performed by a fecond operation. It frequently happens that a piece of porcelain has to go into the enamel kiln four or five times, when a great variety of colours is contained in the painting.

Besides the painting, porcelain is frequently ornamented by gilding. This is performed in a manner very similar to the painting. The precipitate of gold from its solution is ground up with the oil of turpentine, and a very small quantity of the flux. The parts intended to be gilt are covered with this, similar to the painting, and are fired in the same way. The oxyd of gold, in this case, is not defended by the flux, and the oxygen flies off, leaving the gold in its metallic form, firmly fixed to the porcelain. The gold, although metallic, is dead in its appearance, and requires to be burnished. This is another department in the manufacture of porcelain. The burnishers are of hardened steel polished, and the blood stone, and are used in the same way as in burnishing gold and silver vessels. The common kinds of porcelain are painted by means of copper-plate prints. This, however, is more practised in the manufactories of the common earthen-ware. See POTTERY.

PORCELAIN *Earth*, or *Clay*, (*Kaolin*,) in *Mineralogy*, is referred by Kirwan to the second tribe of argillaceous earths.

Colour, white, greyish-white, or reddish, or yellowish-white.

Lustre, 0. Transparency, 0.

Friable and dusty, often compact.

Adheres very slightly to the tongue.

Feels soft but not greasy.

Hardness seldom exceeds 4; but lately some much harder has been found in Siberia Maquart 430. Sp. gr. (which is best taken when hardened by fire) varies with the proportion of its ingredients between 2.23 and 2.4. That of Limoges, which is worked without any mixture, has its spec. gr. 2.341. Brisson 273.

In water it immediately falls into powder. Those of Japan, and St. Iriez in France, are perfectly white; those of Saxony, reddish or yellowish; those of China, and Cornwall, are mixed with particles of talc and mica.

In general porcelain earth is infusible in our furnaces, as Cronsted remarked; but, in manufacturing this earth, some fusible ingredient is commonly added; however, nature sometimes furnishes these ingredients with the earth, and to this compound we cannot refuse the name of porcelain earth. According to Mr. Hassenfratz, to whom mineralogy, in all its branches, and the arts connected with it, are much indebted, the porcelain earth of Limoges above mentioned contains, when dried, 0.62 silex, 0.19 argill, 0.12 magnesia, and 0.07 barosclenite. Mr. Wedgwood, in the porcelain clay of Cornwall, found on the contrary 60 per ct. argill, and only 20 of silex; this clay is therefore infusible. When dried by a summer heat, or that of a room moderately warm, it loses about $\frac{1}{100}$ of its weight; in the heat of boiling water as much more; in that of melted lead, and thence to a strong red heat, in which copper melts $\frac{10}{100}$, in all $\frac{12}{100}$; after that no more: The matter thus lost is common and fixed air, but no inflammable air. Hence it appears to differ from the first tribe, or native argill, only in containing silex. It has been suggested, that porcelain clays derive their most estimable properties from a mixture of magnesia. Mr. Nicholson, in his Journal, vol. xii, mentions a porcelain earth, which appeared, upon analysis, to consist only of carbonate of magnesia and silex. Magnesia is said to be of use in porcelain, by diminishing the degree of contraction to which it is liable.

Porter

Porter, a malt liquor, which is a favourite beverage of the inhabitants of London, and other large towns. The diſtinguiſhing characters of this liquor are its deep brown colour, and an agreeable flavour, which it is difficult to de-

fcribe, our language having fo few words expreffive of different taftes. The origin of the name is thus related by the ingenious editor of the Picture of London. "Before the year 1730, the malt liquors in general ufe in London were ale, beer, and two-penny, and it was cuftomary for the drinkers of malt liquor to call for a pint, or tankard, of half and half, *i. e.* a half of ale and half of beer, a half of ale and half of two-penny, or half of beer and half of two-penny. In courfe of time it alfo became the practice to call for a pint or tankard of *three-threads*, meaning a third of ale, beer, and two-penny; and thus the publican had the trouble to go to three cafks, and turn three cocks, for a pint of liquor. To avoid this inconvenience and wafte, a brewer of the name of Harwood conceived the idea of making a liquor, which fhould partake of the fame united flavours of ale, beer, and two-penny; he did fo, and fucceeded, calling it *entire*, or entire butt, meaning that it was drawn entirely from one cafk, or butt; and as it was a very hearty and nourifhing liquor, it was very fuitable for porters and other working people; hence it obtained the name of porter." The houfe of Harwood is ftill a refpectable brewery; but an immenfe trade has, fince the period above-mentioned, arifen, and is divided among feveral brewers.

At firft, the only effential difference in the methods of brewing porter and other kinds of beer, was, that it was brewed from brown malt, and this gave to it both the colour and flavour required. Of late years it has been brewed from mixtures of pale and brown malt, and the colour of the prefent liquor is much lefs than was formerly efteemed requifite: but finding that pale malt yields a much greater portion of faccharine matter than brown, the greateft number of the London brewers have given up the brown malt altogether, ufing pale and amber malt, which is intermediate between the two. From thefe they procure a liquor of proper ftrength, and they give it both colour and flavour, by the addition of colouring matter made from burnt fugar, or by burning the fugar of concentrated wort. All the London porter is profeffed to be entire butt, as indeed it was at firft; but the fyftem is now altered, and it is very generally compounded of two kinds, or rather the fame liquor in two different ftages, the due admixture of which is palatable, though neither is good alone. One is mild, and the other ftale porter; the former is that which has a flightly bitter flavour, from having been lately brewed; the latter has been kept longer. This mixture the publican adapts to the palates of his feveral cuftomers, and effects the mixture very readily, by means of a machine containing fmall pumps worked by handles. In thefe are four pumps, but only three fpouts, becaufe two of the pumps throw out at the fame fpout: one of thefe two pumps draws the mild, and the other the ftale porter, from the cafks down in the cellar, and the publican, by dexteroufly changing his hold to the handle of the next pump, works either pump, and draws both kinds of beer at the fame fpout. An indifferent obferver fuppofes, that fince it all comes from one fpout, it is entire butt beer, as the publican profeffes over his door, and which vulgar prejudice has decided to be the only good porter, though the difference is not eafily diftinguifhed.

By referring to the article Brewing, our readers will obtain correct ideas of the general principles of the art, and under the prefent we propofe to detail the procefs of brewing porter; and alfo to defcribe the utenfils and machines ufed by the London brewers, who, in confequence of the very large fcale on which they conduct their proceffes, have been induced to ftudy, with the moft minute attention, every thing which can tend to improve their beer, or economize the materials; as alfo to diminifh the labour of removing fuch large quantities of liquor from one part of the works to another: in this their grand agent is the fteam-engine, which gives motion to feveral very capital machines.

There are in London twelve houfes, which are confidered as the principal porter-breweries, and from the returns of the excife, we find that the quantities of beer they brewed in the courfe of two years, *viz.* from July 1810 to July 1812, was as follows.

	Barrels in 1810 and 11.	Barrels in 1811 and 12.
Barclay and Perkins, Borough	264,405	270,259
Meux, Reid, and Co., Liquor-pond-ftreet - - - -	220,094	188,078
Truman, Hanbury, and Co., Brick-lane - - - -	142,179	150,164
Whitbread and Co., Chifwell-ftreet	122,316	122,446
Calvert and Co., Thames-ftreet	105,887	108,212
H. Meux and Co., Marlborough-ftreet - - - -	103,152	102,403
Combe and Co. - - -	81,761	100,824
Brown, Parry, and Co., Golden-lane	72,367	—
Goodwynne and Co., Wapping	85,181	81,022
Elliott and Co., Pimlico -	58,042	58,385
Cocks and Campbell -	—	51,474
Taylor - - - -	46,222	51,220
Clowes, Maddox, and Newbury, Tooley-ftreet - -	36,872	34,010

Of thefe works, the firft that had a fteam-engine, and the moft complete in its arrangement of the utenfils, is Mr. Whitbread's in Chifwell-ftreet. This gentleman having permitted our draughtfman to take drawings from the moft interefting parts of his extenfive works, we fhall proceed to explain them, with the affiftance of *Plate Porter Brewery. Figs.* 1. and 2. of this plate are elevations of the whole brewery, being intended to fhew the connection of all the parts at one view; but we muft premife, that thefe elevations are in a great degree imaginary, and are not to be confidered as taken upon any particular planes, becaufe the different erections would then fall one behind the other, fo as to hide them from the view; they are therefore reprefented in fuch fituations as would be moft convenient for explanation; but the relative levels, as alfo the dimenfions of the individual veffels, are correct. A A, (*fig.* 1.) is the building containing the fteam-engine, which is of twenty horfes power, and gives motion to all the machines by a wheel on the axis of the fly-wheel, turning another upon the horizontal fhaft, and this leads to the mill, where it turns the great horfe-wheel B B. This wheel drives feveral other wheels, to convey the power in different directions. It was the original firft mover of the mill; and when, (by the invention of Mr. Watt,) the fteam-engine was rendered applicable to turn machinery, the horfe-wheel was very judicioufly retained, as by this means, if the engine fhould break, or be difabled, during the procefs of a day's brewing, the work can be continued by putting the horfes to the wheel. This is a great advantage, becaufe the delay of a few hours in pumping up the beer, in more than one of the ftages, would certainly produce a premature fermentation, and fpoil the whole quantity. The water for the brewery is raifed from a deep well by a pump placed in it, and this is worked by cranks and rods, *b*, from the beam of the engine. The well is fituated out in the yard, and the cranks are placed in an arched paffage, which leads from the engine-houfe to the well. The

pump, by means of a pipe *d*, forces the water up to an immenſe reſervoir, called the *liquor back*, placed at a ſufficient elevation to ſupply the whole brewery. In *fig.* 1. this reſervoir is repreſented as placed over the ſteam-engine, which indeed is its uſual poſition in the large London breweries, but in Mr. Whitbread's it is erected over ſome buildings which could not be ſhewn in our plate: from this the reſervoir pipes are laid, to convey the water to any part of the works where it may be required. The principal of theſe are to the coppers B, of which there are three, placed cloſe together, but only one can be ſeen. C is the chimney for it, and the ſame roof, D, covers them all. The water, being heated in the coppers, is conducted by a pipe, *e*, to the maſh tuns E: one of theſe is placed immediately before each of the coppers, though only one is to be ſeen in the view. During the proceſs of maſhing, the malt is kept conſtantly ſtirred by machines in each tun, which receive their motion from the ſteam-engine by the ſhaft *f*: this paſſes over the centre of all three, and by means of bevelled wheels, gives motion to a vertical axis in the centre of each tun, which are the principal axes of the machines. The malt, previous to maſhing, is ground, or cruſhed, to render the huſks pervious to the water. In moſt breweries it is ground between millſtones, ſuch as are uſed for grinding corn, but in theſe works it is broken between iron rollers, *g*, *g*, ſimilar to thoſe uſed for flatting iron: they are 18 inches in diameter, and two feet ſix inches in length, and are ſituated at ſuch a diſtance aſunder, that only a piece of thick brown paper can be paſſed between them; they are turned by wheels from the long horizontal ſhaft *a*, and immediately above them is a third roller, which has a number of deep flutes, or cavities, cut in it, from one end to the other, and theſe, as it revolves, become filled with malt from the hopper above, and then deliver it to the two rollers, which, being in motion, take it between them, and cruſh all the grains flat. By this, which is called a feeding roller, the ſupply to the rollers is kept conſtant and regular, without which they would be in great danger of clogging up, or ſetting faſt. The malt, when it has paſſed through the rollers, is completely broken, even its moſt minute grains, but very little of it is cut into flour; for the huſks of the malt, though cracked ſo as to admit the water readily to the contents, ſtill prevent the flour being ſeparated. This is a great advantage over the method of grinding, becauſe that produces a great quantity of flour, which is the richeſt part of the malt, but when it is ground fine, and ſeparated from the grain, it does not yield ſo much extract in the maſh tun, as when it is preſerved in the grain, and the huſk ſufficiently broken. This is becauſe the flour, when immerſed in the water, and wetted, forms a ſort of paſte, which at firſt abſorbs a conſiderable portion of water, but will not afterwards quit it, ſo that very little extract is obtained from that portion of the malt which is ſeparated from the grain, in the ſtate of flour. The ſtore of malt, before it is ground, is kept in the malt lofts over the mill, as repreſented. When it is brought in waggons to the yard, cloſe by the mill, the ſacks are drawn up by the tackle at F into the loft, and here the ſacks are ſhot down, through holes in the floor, into the great ſtore malt lofts, and from theſe, as it is wanted, is drawn out, through ſhuttles, into the hoppers of the rollers *g*, *g*. The ſtore lofts extend much farther than we have been able to repreſent them in *fig.* 1, but may eaſily be imagined, as they are only a repetition of eight or ten of thoſe ſhewn in the figure, the ſame loft extending over the whole, and the ſame ſack tackle drawing up the ſacks from the carts in the yard; though this, of courſe, is not ſituated at the end of the mill over the pumps, but at the ſide, where it could not have been ſeen. The malt, after paſſing through the rollers *g*, *g*, deſcends into a cheſt, whence it is conveyed to the malt binns over the maſh tuns E, by the motion of an inclined ſcrew *h*: this is a wooden trunk or trough, in which the ſcrew is fitted to revolve, and thus gradually puſhes or raiſes the malt which is contained in the trough, from the lower end of it to the upper, which, being within the malt binn, and at the farther end of it, the ſcrew completely fills, by diſtributing the ground malt at all parts of its length. The ſcrew itſelf is formed of thin iron plates, bent into a ſcrew, and faſtened, by nails, to a central wooden axis, which revolves by the mill. When the malt is wanted for maſhing, it is let down from the binn into the maſh tuns, through ſluices, or ſhuttles, in the bottom of it, and curtains are hung up all round from the binn to the edge of the tun, to prevent loſs from the duſt or flour of the malt flying in the air. After the proceſs of maſhing has continued a ſufficient time, the extract or wort is drawn off from the maſh tuns into other tuns, G, beneath, which are called the under-backs; here it remains only till the coppers are ready to receive it; and it is thrown up by the pump, H, into the copper-back I. This is a ſhallow ciſtern placed above the coppers, and from it the wort can be admitted into any of the coppers, or into their pans: theſe are veſſels which are placed over the coppers, and their contents receive heat from the ſteam raiſed by the boiling of the copper itſelf.

To underſtand this ſee *fig.* 3, which is a ſection taken through the centre of the copper. A A is the fire-grate, B B C the copper itſelf, containing 350 barrels; its top is a dome, and has a cylinder, G, riſing up from it: F F is the pan, erected upon the top of the copper, and encloſing the dome C, within. The pan contains 250 barrels of liquor, which is heated by the ſteam riſing into the cylinder G, and thence deſcending by pipes *d*, *d*, down into the liquor, and bubbling up through it. The heat communicated through the dome alſo aſſiſts in heating the contents of the pan. There are two valves in the head G, which are kept ſhut by ſteelyards and weights; but theſe being opened, the ſteam of the copper is allowed to eſcape through a copper pipe or chimney, K, (*fig.* 1.) into the open air. E (*fig.* 3.) is an iron door, to allow entrance, into the copper, and alſo to put in the hops; it is ſituated on the top of a cylinder riſing from the dome, and is fitted ſo cloſely by grinding, that it is ſteam-tight when ſhut, and forced down upon its ſeat by a ſcrew. Two flues proceed from the fire-grate at the farther end, and conduct the flame and heated air round in oppoſite directions, as ſhewn at D D, to the chimney, which is placed over the fire doors, and thus the heat is applied to the ſides, as well as to the bottom of the coppers: this, as the figure ſhews, is made concave beneath, to allow a greater action to the fire. The chimney is open at the bottom, and, therefore, the draught it occaſions through the flues is only by the lateral action of the current of air, occaſioned by the column of rarefied air in the chimney; but this draught can be cut off, when it is required to damp the fire, by ſhutting up two iron doors at the ends of the flues, and then no air can paſs through the fire. In ſome breweries, doors are provided to ſhut up the bottom of the chimnies, and thus increaſe the draught, by compelling all the air which enters the chimney to paſs through the fire-grate, and thence by the flues into the chimney; this cauſes the copper to boil much quicker, but the violent heat ſoon deſtroys the copper at the bottom, by burning or melting it. When the hops are boiled in the copper, they are kept in conſtant motion, to prevent their lying upon the bottom and burning to it. This is done by a machine called the *rowſer*, contained within the copper; it conſiſts of a vertical ſpindle, *e*, in the centre of the copper, which at its lower extremity has a croſs arm, *g*, curved, to correſpond with the bottom, and

from this a number of loops of heavy chain are ſuſpended, to drag round upon the copper when the ſpindle is turned, and by this means the hops are raked over and continually diſturbed. The ſpindle paſſes through a ſtuffing-box in the centre of the top, G, of the copper, and is turned round by a wheel *f*, engaged with another upon a ſhaft receiving motion from the engine. The direction of this ſhaft is ſhewn dotted in *fig.* 1, at *x*, but is there vaſtly extended in length, as is alſo the ſcrew for the malt, becauſe the engine and mill in reality ſtand in the line of the houſe containing the coppers and maſh tuns, and at the end of them, in which poſition it would have been hidden by the building. The ſame ſhaft, *x*, alſo gives motion to the hop tackle, for drawing the hops up to the top of the copper, where they are thrown in at the door of it, E, *fig.* 3. The rowſer can be drawn up from the bottom of the copper when it requires to be cleaned, for which purpoſe its ſpindle is ſuſpended by a ſort of tackle, that will quickly raiſe it up ſix or ſeven feet. The copper is provided with a float, to ſhew the height of the liquor within it: this conſiſts of a ſtrong wire, paſſing down through a tight ſtuffing-box in the top of the copper, and ſuſpending a ſtone at the lower end of it: from the upper end of the wire a line is conducted over pulleys, which has a ruler or rod divided into feet and inches ſuſpended from it, with a weight greater than the weight of ſtone when it is ſuſpended in the liquor, but leſs than the weight of the ſtone when it is drawn up out of the liquor. In this ſituation the ſtone will always be at the ſurface of the water, in the ſame manner as if it floated, and will ſhew the height of the liquor in the copper. There are ſeveral pipes and cocks belonging to the copper, which are as follows: a pipe leading from the liquor back to introduce water into it; this has a cock formed of two paſſages, one admitting it to flow into the pan, and the other conveying it by a ſhort pipe into the copper itſelf, and the handle being turned in one direction or the other, ſhews which way it will run, or turned in another direction it ſtops up the pipe; there is alſo a hole in the bottom of the copper back, through which the contents run down into the pan, but can be cloſed by a plug, and near it is a pipe leading down through the pan into the copper; this is cloſed by a valve, which can be opened by a lever and ſcrew, when it is required to convey the wort from the copper-back into the copper itſelf; there is alſo a valve, which communicates at once from the pan down into the copper. From the bottom of the copper is a large cock with a pipe *c*, which runs horizontally over all the three maſh tuns, and at every one a branch deſcends beneath the bottom of the tun, and turns up, with two or three ſmaller branches, leading into different parts of the bottom, by which means the hot liquor is admitted from the copper into the tun; it enters in different places at the ſame time, a precaution which is very neceſſary to diſtribute it equally through the whole of the malt in a tun, which like this is twenty feet in diameter; but to do this more effectually, the tun has a falſe bottom perforated with ſmall holes; upon this the malt lies, and the water, being introduced beneath it, flows upwards through the holes in all parts at once.

The maſhing machine, (ſee an elevation of it in *figs.* 4. and 5.) is compoſed of ſeveral endleſs chains, R, extended over two wheels in the manner of chain pumps, and the links of the chains have rakes, *d*, fixed upon them, and as the wheels revolve, aſcend and deſcend through the whole depth of malt contained in the tun, and thus effectually ſtir up the whole to incorporate it with the water. That this action may be performed in all the parts of the tun, the frame containing the wheels and chains is adapted to have a progreſſive motion round in the tun, by turning round upon the vertical axis, D, in the centre. This axis has a bevelled wheel, E, upon it, which turns another upon the end of a horizontal ſhaft F, carrying the wheels, *e*, for the chains R, and extending from the centre of the tun to its circumference, that end being ſupported in a frame S, which reſts with wheels upon the rim or edge, T, of the tun: the interior end is ſuſtained by a frame S, (*fig*, 5.) fitted upon the vertical axis, D. Near the bottom of the tun another horizontal ſhaft, V, parallel to the former, is placed, and has upon it the lower wheels, *e*, for the endleſs chains of rakes. The pivots of this ſhaft are ſupported in the ſame frame S, as the upper: this being, as before mentioned, fitted upon the central axis, D, at one end, and the other end reſting with wheels upon the edge, T, of the tun, it may be made to traverſe round the tun. This is done by having a ring of cogs fixed upon the edge of the tun at T; and an endleſs ſcrew, which is ſupported on the frame S, engages the teeth. By means of bevelled wheels, *l*, this ſcrew is turned ſlowly round from the upper axis, F, of the chain wheels; and it can, by means of a ſmall handle, be diſengaged from the motion, or it can at pleaſure be engaged with either of two different pairs of the bevelled wheels, one giving it a ſlow motion and the other a much quicker; the firſt being uſed to traverſe the machine round the tun till the malt is completely wetted, and then the quicker motion is uſed to maſh the malt up thoroughly. This machine is the invention of Mr. Cooper, who had a patent for it, and has made great numbers. Several other ingenious machines have been invented, but are not yet in general uſe; one by Mr. Sylveſter, another a patent by Mr. W. Jones; (ſee Repertory of Arts, firſt ſeries, vol. ix.); a very ſimple one by Mr. Goodwynne, which he emyloys in his own brewery; a fifth kind of machine is deſcribed in our article Brewing. Mr. Jonathan Dickſon has a patent for a method of making maſh tuns in caſt iron, by which the very heavy expences of conſtantly repairing, and often renewing, wooden veſſels is reduced to a trifle. Meſſrs. Barclay and Perkins have one of theſe in uſe at their brewery. The maſh tuns at Mr. Whitbread's brewery are lined with thin ſheet copper, applied in the ſame manner as the ſheathing of a ſhip, to prevent leekage, and keep the veſſel ſweet and clean. The maſh tuns are ſupported upon a framing of timber, as ſhewn in *fig.* 1, which leave room within them for the under-back G. The malt-binns are ſupported over them by an aſſemblage of pillars between each of the tuns; and to give greater ſtrength to the horizontal beams 1, which are beneath the binns, other horizontal beams, 2, are placed at a conſiderable height above them, and the two pairs being connected by framing and oblique braces, they form a truſs frame ſimilar to a roof, which will bear the weight of the binn, when full, without ſinking. The pipe 3, which draws off the wort from the under-back, is conducted to the three-barrelled pump at H, which is worked by the mill: this elevates it to a trough, which extends over the whole length of the copper-back I, and by means of a plug in the bottom the wort can be let down into it.

When the wort has been boiled in the copper with the hops, both together are run off, at *k*, into the jack-back M: this is in reality a large ſtrainer, to ſeparate and retain the hops. It is a very large back, provided with a falſe bottom, compoſed of caſt-iron plates pierced with ſmall holes. Through theſe the liquor drains, when the pipe, *l*, from the bottom of the back is opened, and the hops are left upon the falſe bottom: the pipe, *l*, is conducted to the pump at H, and this raiſes the wort up to the ſame trough, over the copper-backs I; but inſtead of being run into theſe it is conveyed forwards, by a ſucceſſion of troughs, and diſtributed into the different coolers N, N. Theſe are large backs, and very ſhallow, ſeveral being placed in ſucceſſion over each other, and the windows of the building are made very open,

to admit a current of cold air, to carry the heat off from the beer. In these it remains a sufficient time, till it is cooled to the temperature desired, and then it is drawn off from the coolers into the fermenting house. This is a very large building, placed adjacent to the engine-house. A section of it is given in *fig.* 2: here *p* is the copper pipe, proceeding from the coolers (having numerous branches to all of them), to the gyle-tuns, or squares P, which are large open vats, of sufficient capacity to contain the beer of a whole brewing; here yeast is put to it, and the fermentation commences, and having continued a sufficient time, the beer is distributed into the small tuns, Q, called rounds, where the fermentation is concluded, and the yeast, as fast as it is produced, flows over by a spout into the troughs *m*, which are placed between every two rows: this cleanses the beer, by the separation of the yeast from it; and as by the division into small quantities, (for the rounds only contain nine barrels each,) the temperature is lowered, and as the disposition to fermentation gradually subsides, the beer becomes fit for storing in the vaults or under-ground cisterns T, that it may be kept, till by age it becomes fine and fit for the table. The squares P, (for there are two, one behind the other,) are 22 feet by 24, and 9 feet deep, so that their content is nearly 800 barrels each. The pipe *p*, from the coolers N, (*fig.* 1.) has a branch proceeding to each square, and a double-passaged cock, 4, which will admit it into either, according as the handle is turned to one or the other. The pipe itself proceeds in an inclined direction to the bottom of the square, as shewn by the dotted lines, and thus introduces the beer in the centre, by which means, if there is any variation of temperature in the contents of the square, and that which has recently entered, it will sooner be brought to an equality.

Mr. Richardson, who conducts the brewing at Mr. Whitbread's works, has made an arrangement which deserves particular notice, and is worthy of imitation by other brewers. The pipe, *p*, is made of thin copper, and is enclosed within another pipe, the space between them being supplied with a stream of cold water. To effect this, the main ascending pipe, from the well to the liquor cistern, is not in reality carried up direct, as shewn by *d*, in *fig.* 1, but is placed in the angle of the fermenting house at *d d*, *fig.* 2. A branch, 5, proceeds along the wall thereof, then makes a turn, and joins the external pipe *p*: from the other end of this a branch is conducted to return the water to the main ascending pipe *d*, and in this there is a cock between the two branches, and another upon the branch: now the latter being shut, and the former open, the water ascends at once up the pipe from the well to the reservoir; but when the beer is to be drawn off from the coolers into the squares, the cock in the main pipe, *d*, is shut, and the other opened, by which means all the cold water which the pump throws up from the well is forced through the space surrounding the pipe *p*, in which the beer flows, and thus cools it very effectually. To determine the temperature, the bulb of a thermometer is placed in the centre of the pipe, and its tube comes up through it at 6; then a man is stationed to watch this, and when he observes it sink to the degree at which it is determined that the beer shall be left to ferment, he opens the cock and permits the beer to flow into the square; but still continues to observe the thermometer, and if it sinks lower he opens the cock wider, to admit the beer to flow quicker through the pipe *p*, that it may not be so much cooled by the flow of the cold water; or, if this is not sufficient, he regulates the quantity of cold water, by means of the cocks in the main pipe and the branch: on the other hand, if the thermometer indicates that the beer is not sufficiently cooled, the cock is closed a little; this retards the passage through the pipe, and lowers the temperature, by subjecting it for a longer time to the action of the cold water. By this simple contrivance, the brewer is at a certainty that his liquor has been put to ferment in the square or gyle-tun P, at the exact heat which he intended, a circumstance which was before very uncertain; because, being drawn from so many different coolers, some would of course be less cooled than others, from their different situations, and it could only be guessed what temperature all these different degrees of heat would make when mixed together in the square, and the larger the scale of operation, the more uncertainty; because such large bodies of liquor take a considerable time to flow, and by passing such great lengths of pipes generally lose some heat; but it cannot be guessed how much. In Mr. Richardson's method, this is accurately determined, and capable of regulation. A long thermometer is fixed in the sides of the squares, to shew the temperature of their contents, and this is found to increase during the fermentation; no yeast is removed from the beer in this stage, indeed scarcely any is formed, for though a very large white head collects upon the surface, it is only light bubbles which instantly fall by the least agitation. The fermentation in the squares is generally concluded in thirty hours, and then the beer is removed to the rounds for cleansing from the yeast. It is first run off by a pipe 7, from the squares, into the filling up vessels R, R, which are in reality placed in the space between the two squares; but could not be so represented. When these are full, the pipe is shut, and another cock, 8, opened, which permits the beer to flow through pipes 9, conducted beneath all the rounds Q, Q; and from these, cross branches are conducted between every two rows, and by short pipes introduce the beer into the casks: thus they are all filled at once, and then the cock, 8, is shut. The casks are 240 in number, being arranged in sixteen of the rows which are seen in our figure, though only eight are drawn there; and each row contains fifteen of these casks. The troughs, *m*, between each pair of rows extend the whole length to receive the yeast produced from them, which in this stage of the fermentation is caused to flow off as fast as it is produced; and by this means it is that the fermentation is allayed, because the yeast which constantly keeps it going on, is not suffered to rest upon the surface of the beer. To render this effective, the rounds have close heads, and rather inclined to one side, where is a spout to conduct the yeast into the trough, therefore this spout is at the highest part; and there is no considerable surface exposed, upon which a head of yeast can float, to keep up the fermentation. But as the rounds gradually diminish in content, they are filled up by fresh beer from the filling-up tuns R, which were previously filled, as a reserve for that purpose. A pipe from the bottom of these enters into a small cistern S, where its orifice is closed by a valve. This is opened by a wire, which is connected with a lever, and a float, which floats upon the surface of the liquor in the cistern; and this is, by means of the communicating pipes 9, kept at the same level with the surface of the beer in all the rounds; there being a free communication amongst them all. Now when, by the wasting of the yeast, the beer in the rounds sinks, the float in the cistern sinks, and opening the valve, admits a sufficiency of beer from the filling-up vessels to restore the level, and then the valve closes again. To prevent the beer in the filling-up vessels having an exposed surface, and to carry off the yeast from them as fast as it is produced, a moveable or floating head, 10, is adapted to the tun. This is a slightly concave pan, or dish, of plate iron, which has a pipe fixed perpendicularly down from the

centre of it, and paffing through the bottom of the veffel, in a ftuffing-box. This difh floats upon the furface of the beer in the filling-up veffel, and as it is not quite fo large as the infide of the tun, the yeaft runs over in this fpace, and, falling down the pan to the central pipe, runs through it into troughs placed beneath, which convey it, in common with the produce of all the other cafks, to a tank, or receptacle, funk in the ground. From this tank the yeaft is raifed by a pump into cafks, in which it is fent away, for the ufe of bakers, diftillers, and others who employ it. Whilft remaining in the tank, a confiderable portion of beer, which the yeaft carries over with it, drains away; and this is drawn off by a pump, which drawing from a lower level than the yeaft-pump, raifes the beer into a different ciftern; and here it remains 48 hours, to ferment and cleanfe itfelf. It is then pumped up into fhallow fettling backs, V, V, V: in the higheft of thefe it remains fome time to fettle, and depofit any yeaft it may contain, and is then drawn off into a fecond, and then to the third, by which it becomes clear, and is good ftrong liquor, though unpalatable; but being introduced into the fquare, at the fame time with a fucceeding brewing, it adds to its quantity, without injury of the quality. By this means, no wafte takes place in any department of the work.

When the beer has been fufficiently fermented, and the flow of yeaft ceafes, by which the brewers fay it has fufficiently purged itfelf, it is drawn off from the rounds, Q, to be ftored. That is done either in large tuns W, or otherwife in the cifterns, or underground vaults T: the former is the general fyftem of the London brewers; but the latter, which is only practifed at Mr. Whitbread's, is undoubtedly the beft method, becaufe of the equality of temperature they preferve both in fummer and winter; and their durability, compared with the wooden vats, is no fmall recommendation. Many breweries have wooden ftore vats of immenfe capacity, being as much as 40 feet in diameter, and 20 feet deep. They are placed upon timbers, and fupported by pillars, that fmall cafks may be kept beneath them; and the beer can be drawn off into thefe, when it is to be fent away from the works. The vaults, T, T, are arched, and lined with ftone, well bedded in cement, or pozzolana, and the joints very carefully made. They were built under the directions of the late Mr. Smeaton; but the Roman cement, which has been difcovered fince his time, would be the beft material for jointing and lining them. A very fuperior cement of this kind, which is now manufactured in the north of Yorkfhire, may be procured at Mr. Atkinfon's wharf, Narrow-wall, Lambeth, and would enable brewers, who choofe to adopt the cifterns, to have them made perfectly tight; whereas in thefe works they had at firft much difficulty, from the defective nature of the cement; though they have remedied this, by employing refinous fubftances in the joints. Each ciftern contains 4000 barrels, and the ftore is thus kept without the lofs of any room in the building; a great confideration in London, where the rent of premifes is fo high, not to mention the faving in the repairs, and renewal of the wooden vats.

Mr. Richardfon has applied an ufeful contrivance in this brewery, for cooling the beer previous to ftoring it in fummer time: it is done by collecting the beer from the rounds, Q, into a ciftern thirty feet fquare, funk in the ground, and having a copper pipe conducted round its fides, making three turns in it: through this pipe a conftant ftream of cold water is conducted, in the fame manner as before defcribed, and this cools the beer to as low a temperature in fummer as it will naturally have in winter, and then it is not liable to any fermentation in the ftore vats, which probably takes place in a flight degree in the ordinary procefs, and is one reafon why beer brewed in fummer is feldom fo fine as if brewed in winter. In this ciftern the beer, being kept quiet and cool, depofits fome fediment, apparently of farinaceous matter, which, if the flighteft fermentation exifted, would be held in the beer, and make it turbid; but here it feems to depofit more, and fine itfelf to a greater extent, in a very fhort time, than it would for a long period in the ftore vats; for we fhould obferve, that one principal object of ftoring the beer is, that it may by age become fine and tranfparent, which it does by very flowly depofiting the excefs of vegetable matter, at the bottom of the vat, in the form of flime: but if the flighteft fermentation is excited in the vat, it is put into an agitation, which wholly fufpends this depofition, as long as it lafts; hence the great advantage which the brewers have found from employing fuch large vats as are not liable to fudden variations of temperature; and, for the fame reafon, fubterraneous vaults are better than either.

We have now defcribed the whole of the brewery, excepting only the feveral ftore-houfes for the hops and coals, of which very great ftores muft be kept, for fuch extenfive works: the latter are kept in the lower parts of the buildings, in the vaults or arches upon which the coppers are erected, and any other convenient part of the ground floor; and, in like manner, the hops are ftowed away in large bags, in the lofts over the malt ftores, or any other parts. The number of the rounds, Q, in the fermenting houfe is not correctly reprefented in the drawing, nor the extent of the ftore vats W, which laft, at Mr. Whitbread's brewery, are fituated in a large eftablifhment on the oppofite fide of Chifwell-ftreet.

The managment of the brewing is thus conducted: A fufficiency of pale and brown malt, mixed, is broken between the rollers two or three days before it is wanted; and for this reafon, the malt-binns are made large enough to contain 400 quarters of ground malt. Some kinds of malt, which, the brewers fay, have too much *fire* in them, are found to improve by keeping fome time before they are broken; but a few days keeping after they are broken will produce the fame effect. The water is pumped up into the refervoir till it is full, and in this ftate the work begins, at two or three o'clock, by lighting the copper fires, and the engine fire, filling the coppers with water, and alfo their pans. The mafh-tuns have the required quantity of malt let down from the binn, the curtains before mentioned being hung up to prevent the duft flying. All this is done by a few men, and the liquor (water) in the coppers is heated to the proper degree, which is generally about 150° for the firft mafh, its quantity being proportioned to the quantity of the malt, nearly in the proportion of two barrels to the quarter. But both thefe circumftances vary in different breweries, and from various caufes, as has been explained under BREWING; though, we fhould obferve, that the remarks there made, refer rather to the procefs of brewing on a fmall fcale, than in the large way of manufacture; and though the principles are the fame, the actual heats in the large way are much lower, becaufe the lofs of heat in the procefs is fo much lefs in the large veffels.

The liquor being heated is *turned on*, that is, introduced into the mafh-tun, by opening the cock, *e*, (*fig.* 1.) and admitting it to flow up through the malt, till in ten minutes time it has completely filled it: the mafhing machine is now fet in motion by the fteam-engine, and works round the tun, with the flow motion for twenty minutes; then the quick motion is caft on for four minutes to complete the mafhing; and after this it ftands ftill for two hours to

make the extract, and settle clear. The tap or cock into the under-back is now set running to drain off the wort, and this is left open, until the water for the second mash is sufficiently heated. This is the water which was at first filled into the pan; and immediately the first liquor quitted the copper, the contents of the pan were let down into it; and having acquired some heat while in the pan, is soon sufficiently heated, perhaps to 160°, and at the rate of one barrel to the quarter, being only half the quantity of the first mash, because so much of that is left in the malt. The mashing machine is worked for this as before, but it only stands one hour instead of two, because the malt was completely saturated before: in this period the first mash is pumped up into the copper, and the hops being added to it, the boiling is begun. The under-backs being thus cleared, the second wort is run off into them, and stands to drain from the malt, till the third liquor (water) is ready: this has been heating in one of the other coppers, till it is at 180°, and is then, in its turn, let down into the mash tuns, is mashed, and stands an hour, during which the second wort is pumped up into the copper back of the second copper, ready for boiling, and is admitted into the pan, that it may gradually heat. If a fourth mash is taken, that no waste may be made, it is heated in another copper, and is not brewed that day, but is reserved for the next brewing, and is then used instead of fresh water for the first mash. Some brewers do not practise this method, because there is in warm weather some danger of a premature fermentation, called *foxing*, taking place in the wort which is kept; but in cold weather it may be safely done, and is a saving. We have now to attend to the boiling: this is continued for the first wort one hour; and the second, being in the pan, receives considerable heat by the steam rising from the copper. When sufficiently boiled, the first wort, together with the hops, is run off into the jack-back M, and hence it is pumped up to the coolers N. The first wort is placed in these coolers, which, being least exposed to the air, will cool slowest, because the object is to get all the different worts cooled by the same time, ready for fermentation. The second wort is let down into the copper the instant the first is run off; and the hops which are left in the jack-back are filled into buckets, and drawn up by the hop-tackle, to be returned into the copper, for boiling with the second wort; but as this continues for two hours, the third wort is thrown up, towards the end of the time, to the second copper, and the boiling begun; for the instant the second wort is distributed into the coolers, the hops are put to the third wort, and boiled with them for four hours. This boiling of the worts, coagulates great part of the solid matters which the wort extracted from the malt, and by thus collecting those minute particles which were before diffused so equally throughout the wort, as only to render it cloudy, into distinct fecula, they are disposed to deposit themselves in the coolers, which they do in great quantities; and it is by this process that the beer is first separated from the grossest part of the extract. The cooling is conducted as expeditiously as possible, and when sufficient, as shewn by the thermometer, all the three worts together are, as before explained, drawn off into the square P, which contains 800 barrels, which is the full quantity of a day's brewing; the yeast is here put to it, and the fermentation begins, and it is by this process the porter acquires its spirituous quality, and is rendered clearer, from the great quantity of mucilaginous matter which is thrown off in the yeast. The fermentation first shews itself, by the whole body of the liquor teeming with innumerable small bubbles rising to the surface, each enveloped in a thin film of yeast, which, as the bubbles burst, collect into a head or froth, and float on the top of the liquor. The temperature of the fluid increases considerably, and the noise of these bubbles, rising through the fluid, causes a continual singing. Part of the bubbles burst before they arrive at the surface, and the film of yeast which envelopes them, sinks until it is borne up again by the ascending bubbles. These films form at first a white covering to the surface of the beer, which the brewers call the lamb's back, and as the process advances it becomes yellow, having the appearance of rocks; but this yeast is only a thin watery substance, which quickly melts down into a fluid. When the fermentation has advanced so far, that the head of the yeast begins to sink, it shews the process is past its greatest pitch, and the brewer must check it, or it would soon be succeeded by a second stage of fermentation, which produces vinegar. This check is given by the operation of cleansing, in which, as we have before stated, the yeast is carried off as fast as it is produced, and the fermentation gradually subsides.

To review the several processes of the brewery of porter, it should be observed, that it is required, in the mashing, to extract from the malt all the saccharum it contains; but the heat at which this must be done is also favourable for extracting a great proportion of the mucilage and glutinous parts of the malt, which must afterwards, in some degree, be separated from the wort, and the portion which is left will determine the flavour and colour of the beer. If the heat of the mashing liquor is too low, it will extract so much of these matters, that all the subsequent processes can never separate them sufficiently to make the liquor fine; and at the same time it will not extract much saccharum. But by increasing the heat, the mucilage becomes, in a measure, coagulated in the tun, and is not extracted in so great a degree, whilst the saccharum is taken up by the wort in a full proportion. On the other hand, an excessive heat carries this too far, for it makes a complete paste of the malt, by melting the gluten, and the whole resembles a hasty pudding. This disaster, which the brewer calls *setting the goods*, spoils the whole process, as a great proportion of the water becomes combined with the malt, in the state of paste, and will not run off; whilst that proportion which does remain unmixed, and can be drained out, has extracted little or nothing, either of saccharum or gluten, from the malt. This state of things takes place, in a greater or less degree, whenever the extracting heat is taken too high: the other extreme we have spoken of. Between these the brewer endeavours to keep, and by his success in this simple point, the quality and strength of his beer will be influenced most materially. No precise rules can be given for the actual heats, as they depend upon the nature of the malt, the heat used in drying it, (the brown requiring less heat than pale); the quality of the water has also its share, and the quantity of malt mashed at once, (because a great mash-tun loses less of its heat during the mashing than a smaller one); also the temperature of the atmosphere.

Having been thus necessitated to extract more of the solid matters from the malt that he wishes to retain, the brewer, in the succeeding processes, turns his attention to the most effective means of expelling the superabundant mucilage, and without losing the sugar, to leave a fine transparent and palatable liquor.

By the process of boiling, the grossest part of the mucilage extracted by the wort is coagulated, and in a manner precipitated into distinct fecula, leaving the liquor, which was before thick and muddy, comparatively clear between the flakes, which are so large as to be individually visible. The boiling also extracts the bitter of the hops, which is

neceſſary to make the beer keep, till it becomes fine and fit for the table; it alſo concentrates the wort, by evaporating a part of the water uſed in the maſhing: on ſpreading the wort thin in the coolers, the fecula ſubſides, and is left behind.

The fermentation in the ſquares, P, does not expel any of the extract matter, but the chief object of it is, to convert the ſaccharum into alcohol or ſpirit, and at the ſame time it diſpoſes the groſſer parts to a more favourable ſtate for the ſeparation which takes place in the ſecond fermentation in the rounds, and by the great quantity of yeaſt which is thrown off, the beer becomes finer, at the ſame time that the production of ſpirit continues, and it loſes its ſweet taſte. When this fermentation ſubſides, the beer is ſtored, and remains quiet, the longer time the better, to become clear and tranſparent; but this is, provided the quantity of hops it had is ſufficient to prevent its becoming ſour, becauſe the extract of the hop is inimical to fermentation, and prevents that proceſs going on in the ſtore vat, which, if it did, would produce vinegar. What is really intended in the ſtore vat is, to depoſit thoſe finer particles of ſuperabundant matter which have eſcaped the other proceſſes, and the beer improves in its ſtrength.

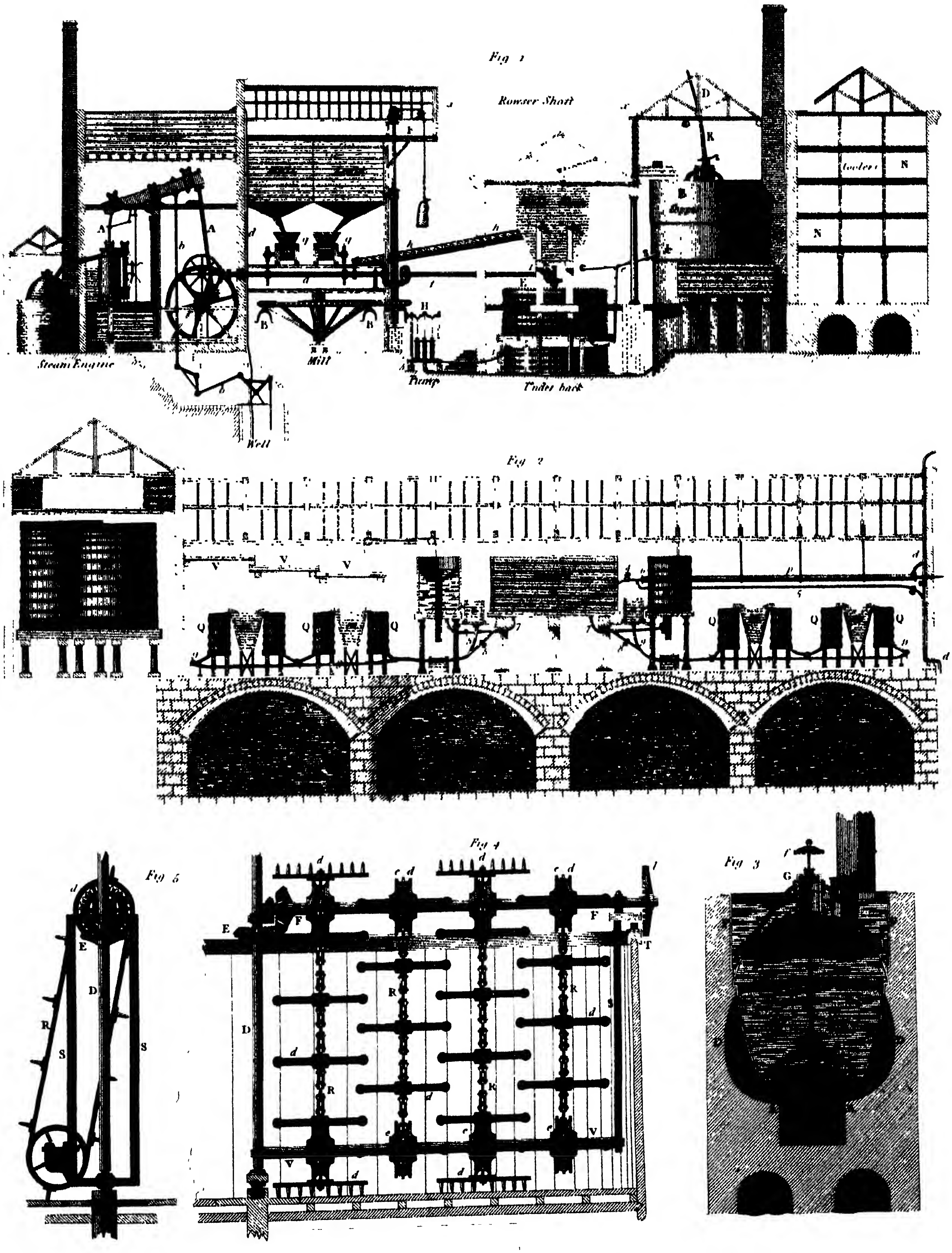
The porter brewed for the ſupply of London is kept a very ſhort time, and therefore has a ſmall ſhare of hops; and as it would not have time to become fine, it is fined by a proceſs on purpoſe, which, indeed, is neceſſary; for if the beer was kept till it became fine, it would, by the ſhaking of carriage, when ſent from the brewery, be rendered cloudy; the beer is therefore ſent away in the rough, and requires fining, which is done by the conſumer putting into the caſk a ſmall quantity of fining, ſent by the brewer with the porter. Theſe finings are made of iſinglaſs diſſolved in ſour beer, made from the wort of the fourth maſh, or ſour beer obtained from the waſte of any of the proceſſes. A ſmall quantity of this fining being put into the caſk, precipitates the minute feculæ to the bottom, and ſoon renders the liquor quite fine.

In Mr. Whitbread's works no *colouring* matter is employed, as he uſes a portion of brown malt; but moſt of the other brewers uſe pale malt, and colour the beer, by the addition of certain colouring matter, which being obtained from burning the ſame ſubſtance that cauſes the brown colour of the highly dried malt, produces a ſimilar liquor, at a far leſs expence of materials, than when brown malt alone is uſed; becauſe the pale malt yields a much greater proportion of ſaccharine matter than the brown, in which a ſhare of the ſaccharum is burnt up in the kiln, only for the purpoſe of producing a colour and flavour which may ſo eaſily be communicated to the beer of pale malt, by a ſmall quantity of burnt ſugar. Many brewers, to avoid the cenſure of the public, who require them to uſe malt and hops alone, concentrate a quantity of their beſt firſt wort, by boiling in an iron pan, and burn this inſtead of ſugar, from which it does not materially differ.

The proceſs, in either caſe, is to put a quantity of coarſe brown ſugar, (or the concentrated wort,) into an iron pan, with a ſmall quantity of water, keeping it conſtantly ſtirred up; it is then ſet on fire, and burnt for a few minutes, to give it the colour and flavour which might be obtained from brown malt. The fire is extinguiſhed by putting on a cover. The reſiduum is now mixed up with water to the conſiſtency of treacle, and makes the colouring, which is put to the beer while working in the ſquare, and gives it very near the ſame colour and flavour it would have derived from being brewed from brown malt.

Some of our readers may have met with pamphlets profeſſing to deſcribe the proceſs of brewing porter, and mentioning a variety of ingredients, ſuch as liquorice, eſſentia bina, treacle, capſicum, ginger, lime, coriander ſeeds, cocculus indicus, &c. &c., but the writer of this article, having viſited nearly all the great porter breweries in London, where he has been ſhewn into all their ſtore-houſes, and examined every proceſs, can ſafely aſſure our readers that no articles more than malt and hops, except the colouring and finings, are uſed in their works, whoſe beer is reputed to be the beſt of any, nor has he ever met with any brewer who employs ſuch articles for brewing porter.

PORTER BREWERY



J. Farey delin

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Pottery

POTTERY, the art of making earthen pots and veſſels; or the manufacture of earthen-ware.

Veſſels capable of holding liquid food, and drink for the uſe of man, would be ſo eſſential to his immediate neceſſities, that their fabrication would doubtleſs be prior to the invention of the humbleſt cottage. Veſſels formed by excavating pieces of wood and leather, were in all probability prior to thoſe of earthen-ware. This manufacture, however, is ſo ancient, that we have no traces to the period of its invention.

From the great perfection in which we find the porcelain of China, as far back as hiſtory will inform us, there is great reaſon to believe, that many centuries muſt have elapſed in bringing it to that ſtate, could we even aſcertain when it arrived at its climax. It is remarkable, that the oldeſt ſpecimen of Chineſe porcelain does not differ in its eſſential qualities from the moſt recently manufactured.

There is ſtrong ground to ſuppoſe, that the art of pottery had been long brought to great perfection in the Eaſt, before it was known in Africa and Europe. It was afterwards cultivated by the Egyptians, from whom it deſcended to the Greeks and Romans.

A ſpecies of earthen-ware was manufactured in Perſia, which was conſidered a great curioſity, on account of its metallic luſtre. Something ſimilar has lately been manufactured in this country, to which the metallic luſtre is given by gold; and another with platina, having the colour of that metal.

The Romans appear to have cultivated this art to a conſiderable extent. The taſte and elegance diſplayed in their form and ornamental decoration, were doubtleſs borrowed from what the Greeks had long before practiſed: the country moſt celebrated for this art was the ancient Etruria. It was the ambition of that enlightened manufacturer, the late Mr. Wedgewood, to equal the manufacture of Etruria, after which he named the village that has grown out of his genius and induſtry; let it, however, be ſaid to the praiſe of this great man, that in his attempt to equal the ancients, he has very far excelled any thing of the kind yet produced, in the firmneſs and compactneſs of body, in colour, and in elegance of form. It may be truly ſaid of Mr. Wedgewood, that he has increaſed the value of the raw material in a greater degree than any other manufacturer. The potteries of this country, prior to his exertions and example, produced nothing but of a flimſy fabric, deſtitute of taſte, and ſcarcely fit for domeſtic uſe. Their beſt production was the common white ware, richly daubed with blue, to imitate the unmeaning ſcenes painted on the Chineſe porcelain: ſince his time the manufactures of Staffordſhire have become celebrated at home and abroad. Among theſe, however, the modern Etruria, occupied at preſent by the ſons of Mr. Wedgewood, ſtill bears a diſtinguiſhed ſway, and muſt continue to be conſpicuous, ſo long as they poſſeſs the ſame ſpirit of improvement, to which their preſent eſtabliſhment owes its exiſtence.

Although very different combinations of the earth, and ſometimes metallic oxyds are employed in the manufacture of earthen-ware, the ductility of theſe compounds, or that which admits of their being moulded into different forms, is peculiar to alumine or argillaceous earth. The natural compounds, commonly called clays, conſiſt of pure clay or alumine, combined with ſilex, lime, and ſometimes magneſia, and frequently alſo with oxyd of iron. In this latter caſe the pottery burns to different ſhades of red, proportionate to the quantity of iron. When magneſia is combined, it gives to it a ſoapy feel, from which it has obtained the name of ſoap-rock. A marked variety of this is called ſteatite.

The clay from which the Staffordſhire ware is manufactured comes from Dorſetſhire, and another variety of inferior quality from Devonſhire. Theſe are both of excellent quality for working, and poſſeſs great whiteneſs when burnt. Theſe clays are valued particularly for the latter property, which ariſes from their being free from iron, which would give them a yellow or reddiſh colour.

The clay undergoes ſuch preparation at the place where it is procured, as to free it from ſtones and many other impurities. In the manufactory of Mr. Wedgewood, the moſt complete in the kingdom, the clay is thrown into a cylinder of caſt metal, four feet high and twenty inches in diameter. In the middle of this cylinder runs a perpendicular ſhaft, with knives as radii at right angles to the ſhaft. Theſe knives are ſo arranged upon the ſhaft, that their flat ſides are in the plane of a ſpiral thread, ſo that by the revolution of the ſhaft the knives do not only cut any thing in their way, but conſtantly force downwards what may be in the cylinder, agreeably to the nature of the ſcrew. Another ſet of knives is inſerted in the interior ſurface of the cylinder, and extend to the ſhaft in the centre: theſe correſpond with, and are parallel to, the moveable knives. The two ſets, the one active, the other paſſive, have the effect of ſheers in cutting the clay into ſmall pieces, while the ſpiral form of the active knives forces the clay in its reduced ſtate out at an aperture at the bottom of the cylinder, from whence it is transferred to a vat, for the purpoſe of mixing the clay with water. This vat is of a cylindrical form, the diameter being about four times the height. In the centre of this vat turns a perpendicular ſhaft, having croſs arms or radii one below the other. Theſe are connected by perpendicular ſtaves, giving the moveable part the appearance of two oppoſite gates, upon the central ſhaft. Theſe gates revolve in the cylinder juſt immerſed in the pulp, the conſtant agitation mixing all the fine particles completely with the water, while the ſtony particles of greater magnitude remain at the bottom. The pulp is now paſſed off from this vat through a ſeries of ſieves of different degrees of firmneſs, which work backward and forward by machinery: this ſeparates the groſs parts from that which is fitted to enter into the compoſition of the ware. We will here leave this refined pulp, to go to the preparation of the flint, a certain portion of which is neceſſary to be united with the clay pulp, in order to conſtitute the potter's maſs.

The flint in its crude ſtate is the common flint uſed for ſtriking fire, which principally conſiſts of pure ſilex. It is firſt placed in a kiln and heated to a red heat; and while red-hot thrown into cold water. This proceſs is to leſſen its aggregation, and make it eaſier to reduce to powder. Mr. Wedgewood reduces the flints into ſmall pieces by means of hammers, which are worked by machinery. The pieces are laid upon a ſtrong grating, ſo that as they become of a certain ſize, they are driven through the diviſions of the grate. After this proceſs they are taken to a mill, which conſiſts of a cylindrical pan, ſimilar to that uſed for mixing the clay with water, but the arms of the upright ſhaft are made to carry large ſtones of great hardneſs: the ſtone is known by the name of *chert*. Theſe ſtones are faſtened to the arms of the upright ſhaft, ſo that the under ſide, which is perfectly flat, may move over ſimilar paſſive ſtones. This cylindrical pan contains a certain quantity of water when the ſmall maſſes of flint are introduced. The flint ſoon gets between the chert ſurfaces, which from their great hardneſs reduce the flint to a pulpy conſiſtence. The finer particles become ſuſpended in the fluid, and are run off from time to time near the top of the pan. This pulp is then paſſed through lawn or ſilk ſieves in a manner ſimilar to the clay, the part which remains in the ſieve being returned to the mill to be ground over again. The pulp is always made to a certain conſiſtence, with a view to know what quantity of flint is contained in a given meaſure, and the ſame with regard to the clay in the ſame ſtate. The two pulps are now mixed together in ſuch proportion by meaſure, that the flint bears a proportion to the clay of about one to five, and ſometimes one to ſix. They are now intimately mixed together, by an apparatus ſimilar to that employed for mixing the clay with the water in the firſt inſtance.

It is a well-known fact that clay, when expoſed to the fire, continues to ſhrink to the greateſt heat of the beſt furnaces. This contraction doubtleſs goes on till the whole of the water is diſſipated, and the clay undergoes fuſion. This phenomenon is more conſpicuous when the clay is pure alumine. Hence we ſhould expect, if the clay were pure, that the ſame degree of heat in ſuch clay ought to produce the ſame decreaſe of volume. The application of this principle to meaſure high temperatures, did not eſcape the ſagacity of the late Mr. Wedgewood. He conſtructed a thermometer which meaſured the degree of heat in which bits of pure clay had been expoſed, by their ſhrinkage. Plauſible, however, as this idea may appear, it became almoſt impracticable, from the circumſtance of the ſhrinkage of different bits, made from the ſame maſs of clay, not being uniform.

It is found that, in proportion as pure clay is combined with the other earths, it undergoes leſs ſhrinkage; and ſince the great ſhrinkage in the manufacture of earthen-ware is attended with other inconveniences, the flint is added for the purpoſe of preventing the ſhrinkage to a certain extent. It will appear that when the ſhrinkage is the greateſt, the ware will be the moſt denſe, and will afford a cloſer fracture. Under theſe properties the articles are leſs fitted to withſtand ſudden changes of temperature. The ſhrinkage may alſo be diminiſhed by pounding pieces of well-burnt clay, and mixing them with the clay that would be liable to ſhrink. This expedient is often reſorted to in making crucibles, which require to be made of the pureſt clay, on account of their eſſential property of infuſibility.

When the flint and clay, in their pulpy ſtate, have been intimately mixed, the next proceſs is to ſeparate the exceſs of water, which is effected by evaporation. The veſſel in which the pulp is placed for evaporation ſhould expoſe a great ſurface, its breadth being about five or ſix feet, its length 20 to 30, and very ſhallow. The bottom is made of firebricks, and the flame of the fire, which is at one end of the brick-work, paſſes along a flue under the bottom. The evaporation is ſlow, on account of the bricks being bad conductors of heat. This inconvenience, however, is compenſated by the uniform conſiſtence which the evaporating maſs acquires. When the evaporation has been continued till the maſs is ſufficiently ſtiff, it is cut out in cubical maſſes, and is next ſubjected to a proceſs, by which the maſs is rendered of uniform ſtiffneſs throughout, and fit for working. This change is brought about in the moſt complete manner, by allowing it to remain in a heap for a conſiderable time. The water in the clay may be conſidered as a chemical compound. Hence we may conceive that the water, by time alone, will conſtantly be tending to uniformity throughout the whole maſs.

The operations by which this effect is facilitated, are, firſt by hand, and ſecondly, by a machine for the purpoſe. The firſt is called *ſloping* or *wedging*, and conſiſts in taking a maſs of clay in both hands, and with a twiſt of both at the ſame time, the piece is ſeparated into two pieces. They are now brought together with greater violence, but in different parts to thoſe juſt ſeparated. The piece is now ſeparated at right angles, and two new ſurfaces brought in contact. This change of ſurface every time, ſometimes 20 or 30 times, effects the uniform mixture of the different parts ſo completely, that if, at the commencement of the operation, the maſs conſiſted of two diſtinct pieces, one black and the

other white, at the end of the operation the mafs would become of an uniform grey colour.

This latter procefs is ufually practifed immediately before the clay is made in maffes of proper fize for working into different articles.

This change is alfo effected with more difpatch by a machine, very fimilar to that firft ufed for cutting the crude clay into pieces.

An upright fhaft works in a cylinder of caft iron; from this the radiant knives work in the plane of a fpiral thread, extending to the circumference of the cylinder. The pieces of clay are thrown into the cylinder in the ftate they are cut out of the evaporating veffel. The knives firft act by cutting them in pieces, and force them down the cylinder like a fcrew. From the bottom of the cylinder extends an horizontal opening in the form of a parallelepipedon, the fection being about fix inches fquare. The clay is forced through this opening, and cut off in lengths of about one foot each. Thefe maffes are again thrown into the cylinder, and paffed through in the fame way feveral times, till they are deemed in a proper ftate. The maffes are now, when time will admit, laid together for fome time, as the workmen find that they work much better for lying longer. This we have accounted for from the equal force of affinity, which tends to eftablifh an equilibrium of the attractive force of the clay for water in every part of the mafs.

Having prepared the material, we will now proceed to defcribe the methods of forming it into articles of various forms. This is fo very fimilar to the methods ufed in the manufacture of porcelain, which we have already defcribed, that we fhall merely ftate fome improvements in the machinery introduced by Mr. Wedgewood. The potter's lathe, which is ufed for throwing the different articles of a circular form, confifts of a perpendicular fhaft about three feet high, having a circular piece of wood at the top, the face of which, by the fhaft, turns parallel to the horizon. The lower end of the fhaft runs in a ftep; the upper part has a neck a little below the circular piece of wood, which works in a focket. Formerly this perpendicular fhaft was put in motion by a wheel, with fpokes faftened upon it, which the workman moved with his foot. In others the fhaft has a crank in the middle, with a long rod working upon it. This being pufhed backward and forward by a fecond perfon, gave motion to the lathe. In the *porcelain* works of this country, as has been defcribed under that article, the lathe is generally turned by a rope paffing from a pulley upon the perpendicular fhaft to a large wheel at a diftance, which is turned by a boy. The firft of thefe methods is convenient, as the workman can beft fuit the velocity to the ftate of the work, which varies very confiderably in throwing the fmalleft article. The labour, however, is fo great, that in throwing large articles there would be great time loft. The two other methods, although they afford much eafe to the workman, are very inconvenient, as the thrower has conftantly to be fpeaking to the turner, in order to get the proper increafe of fpeed. Mr. Wedgewood has the whole of his lathes, both for throwing and turning, turned by the fteam-engine. The perpendicular fhaft of the lathe is moved by an horizontal one, which is connected by two bevel wheels. The horizontal fhaft is provided with a long drum, from which a ftrap afcends to two conical drums reverfed, and working together: this allows the ftrap to keep at the fame degree of tightnefs, while it traverfes from one end of the drum to the other. From thefe drums, which are moved by the principal one, motion is given to the lathe. During the throwing of any article, a feparate piece of machinery is turned by a boy, which caufes the ftrap to move, parallel to itfelf, along the drum of the horizontal fhaft, and at the fame time along the conical drum. This changes the velocity very gradually to its maximum, and returns to its floweft motion, when the workman is finifhing the article thrown; the ftrap is then thrown on to a loofe pulley, which ftops the lathe. The clay is firft portioned into pieces fufficient for the article intended. At the fame inftant that the thrower places the pieces of clay on the face of the circular board, the ftrap is transferred from the loofe pulley, and the motion commences. The boy, by turning a winch, begins to move the ftrap from the fmall end of the conical drum to the large end, when the velocity is at its maximum, and when the thrower, by means of his wet hands and a thin piece of wood, is giving the proper fhape to the clay. At this point he begins to finifh the article, and the ftrap is caufed to move back from the large to the fmall end of the drum, when the work is finifhed, the machine is ftopped, and the thrown article cut off at the bafe with a piece of fmall wire. It is now carried to a proper place to be dried. When it has been dried to a certain extent, which the workmen call the green ftate, it is then taken to the turning lathe, which is fimilar to the common lathe ufed for turning wood. Thefe lathes, in Mr. Wedgewood's works, are turned by the fteam-engine, and as, during the turning of each veffel, the velocity requires to be varied, the motion is communicated from two conical drums, fimilar to the throwing lathe, and the ftrap is made to traverfe the drums by a motion given by the foot of the turner. There is alfo a contrivance for reverfing the motion, by which the turned furface is polifhed.

The fame degree of drynefs which admits of the clay being turned in the lathe, to give it its proper finifh and fmoothnefs, is alfo the proper ftate for fixing on the handles or other appendages, which cannot be effected in the lathe. The parts to be added are previoufly made, and at a proper degree of drynefs are attached to the round work by means of a pulpy mafs, formed by clay mixed with water, which the workmen call *flip*. The joined parts are then fmoothed off with a wet fponge. In this ftate they are taken to a ftove, which is nothing more than a room provided with fhelves, raifed from 80 to 90 degrees of temperature. When they are fully dried, if the articles be of fuperior quality, they are rubbed over with a fmall bundle of hemp, in order to take off any fmall bits left after the turning and handling, and to fmooth thofe parts which cannot be turned. The ware is now ready for the kiln, which is to convert it from a foft and tender ftate to a hard fubftance, called *bifcuit*.

A great variety of pottery cannot be made on the lathe, its not being of a circular form. This is made by two different methods, the one called prefs-work and the other cafting. The prefs-work is formed in moulds made of plafter, one half of the figure being on one fide of the mould, and the other half on the other fide: thefe fit accurately together. The clay is firft made into two flat pieces, of the thicknefs of the articles: one of thefe is preffed into one fide of the mould, and the other into the other fide, the fuperfluous clay being cut away, leaving it a little flufh above the mould. The two fides of the mould are now brought together to unite the two halves of the article. The mould is now to be feparated from the clay, and the article is finifhed as to form. It is now dried to the green ftate, when it is completed with any other parts to be added. All veffels of an oval form, or fuch as have flat fides, are made in this way. The fpouts of tea-pots, and all fimilar articles, are made in two halves in a fimilar way, and are attached to the veffels in the green ftate, when the handles are alfo put on. The handles, which are fometimes of an oval fhape in their fection, others fluted

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through it. This valuable property of biscuit earthen-ware has lately been applied to the construction of vessels for cooling wine and other liquids. The water passes from the inner to the outer surface, and constantly presents a humid surface to the atmosphere, which by evaporation carries off much more heat than would be carried off from dry surfaces. Mr. Leslie has lately made an useful instrument, by taking advantage of this property of the biscuit for shewing the evaporating power of the air.

The next process is to render the biscuit fit to hold liquids, by filling up the pores, and coating the surface with a vitreous substance. This process is called glazing. A great variety of substances may be used for this purpose. Pounded glass would constitute a glazing for earthen-ware, where the colour of the body is wished to be seen through the glazing. The composition for earthen-ware, which we have given in this account, is capable of forming two varieties merely from the nature of the glazing. When the glazing is transparent and colourless, the colour of the body is seen, which having a yellowish tint from the presence of a small quantity of oxyd of iron, it is called cream-coloured ware. When the glazing is rendered a little opaque and of a blueish tint, by the presence of tin or arsenic, and a small portion of oxyd of cobalt, it acquires a milky or opal appearance of a blueish-white colour. The glazing formed with pounded glass, may be considered as a compound of flint and potash, or soda; hence it can be made of different degrees of fusibility by the addition of flint or alkali. These glazes are found to have some inconveniences, the principal of which is their not expanding and contracting equably with the body. The glaze is liable to crack and sometimes peel off. Earthenware glazed with this substance may be frequently observed to abound with innumerable cracks on the surface, which are permeable to grease or any other fluid. Such vessels soon become very disagreeable, especially when heat is applied to them, capable of burning the substances by which they have been penetrated.

No glazing has yet been discovered for common earthenware which is free from the above objection, without the use of lead, which, on account of the poisonous quality of that metal, should, if possible, be avoided. The oxyd of lead, even in its vitreous state, and combined with flint or clay, is so completely soluble in acids, that bad consequences have arisen by eating pickles from jars glazed with lead.

The transparent glaze used for the cream-coloured ware, is generally composed of oxyd of lead and ground flint, in equal weights. White lead is preferred, but it is not so economical as litharge or minium. In the commonest earthen-ware, galena (sulphuret of lead) is made use of. The oxyd of lead and the flint are first ground to an extremely fine powder, and then mixed with water, to give the whole the consistency of cream. The biscuit, being first made clean, is dipped into the pulp, and drained out: it is then turned about rapidly into various positions, to prevent the glaze from lying thicker in one place than another. During this change of position the water of the glaze is absorbed by the biscuit, leaving the solid matter of uniform thickness upon the surface. This part of the process is called dipping. The ware is now placed in the sagars and put in the kiln, exactly the same as in the biscuiting process. The fire is not raised so high, nor so long continued, being only sufficient to bring the glaze into perfect fusion. Dishes and plates, when placed in the sagars for glazing, may be put one upon another, by placing small stands of earthenware between them, presenting three small points only to each of the surfaces. When this ware is brought from the kiln, it is considered finished.

The ware called white ware is made of the same material, and manufactured precisely in the same way, as far as the biscuiting. Formerly it used to be painted after glazing, and had a second firing, similar to porcelain. It is now printed with copper-plate prints almost always with oxyd of cobalt, which makes the figures of a blue colour. It is in this state called blue and white ware, and constitutes an important branch of the Staffordshire pottery. The subjects of the prints are generally vile imitations of the paintings on the Chinese porcelain, which are of themselves shocking.

The printing is performed while the ware is in the state of biscuit, and the glazing laid over the colouring matter. The designs for the ware are engraved upon copper-plates, and prints taken from these, as in common copper-plate printing. The surface of the paper to receive the impression is first smeared over with soft soap. The plate and the rolling-press are constantly kept warm. The colouring, which for the *blue* and *white ware* is oxyd of cobalt, is greatly diluted with some colourless earthy matter: it is ground up with boiled linseed oil, such as is used for printing ink: its consistency, when laid on the plate, being that of soft paste. The paper, prepared as above mentioned, is now laid upon the plate, and passed through the rolling-press. The printed part is now cut out of the paper, and being moistened is laid upon the biscuit. The colouring matter is now instantly absorbed by the biscuit. This being done, the paper is washed from the biscuit in a tub of clean water. The colouring matter will now be seen very plain on the surface of the pottery.

The ware, having received the colouring matter, is now set to dry up the water, and is then dipped in the glazing pulp precisely in the same way as the cream-coloured ware. The glazing material, it will be remembered, differs a little from the latter, in containing a little oxyd of cobalt, which gives it a blueish tint, and gives the idea of greater whiteness. The goods are fired in sagars, as has been already described. The oxyd of cobalt now becomes of a beautiful blue, under the glaze. If, instead of the cobalt, a mixture of the oxyds of iron and manganese be employed, the figures will appear of a black colour, which gives the effect of an engraving, and is much more beautiful and consistent than the cobalt. In some potteries *pencilling* is practised to great extent. This consists in laying on the colours with enamel, after the glazing. This work is very expensive, and is not so general as formerly. This process is so similar to that used in painting *porcelain*, that we shall refer the reader to that article.

Lately, another variety of ware has been introduced, which is by the potters called *lustre:* it consists in fixing gold or platina upon the surface of the glazing. The substance from which the platina lustre is procured, is obtained by dissolving platina in equal parts of the nitric and muriatic acids with heat. When the whole is dissolved, add to the solution a solution of muriat of ammonia, but yellow precipitate will fall to the bottom: continue to add the latter till no more is precipitated: decant off the clear liquor, and add fresh portions of hot water, till it becomes tasteless: drive off the first portion of water by heat, and preserve the dry powder for use: let this powder be ground, with a small portion of enamel, in oil of turpentine: spread this thinly over the glazed surface of the plain earthen-ware above described. The ware is now to be exposed to the heat of an enamel kiln, which is a red heat. The platina assumes its metallic form, which acquires greater brilliancy by the presence of the glaze.

The precipitates from gold may be laid on in the same way. The glazed ground, however, on which the gold is

laid, is of a brown colour by adding the oxyds of iron and copper to the glazing matter. By this means the yellow colour of the gold with the brown glaze, gives the luſtre the colour more of copper than of gold. It is probable that the luſtre is, or may be produced by ſmearing the glazed ſurface with the liquid ſolution of the metal, in a very dilute ſtate. The liquid may contain a little gum, and a little enamel mixed with it, when ſpread upon the articles to be luſtred.

A very coarſe earthen-ware made in Perſia, which we have alluded to in a former part of this article, poſſeſſes metallic luſtre, which is doubtleſs given by gold in the way juſt deſcribed.

The moſt perfect pottery, particularly ſo far as regards excellence of workmanſhip, has been manufactured by the late Mr. Wedgewood, and ſince by his ſons. Among the moſt ſuperb of their productions are their imitations of jaſper, manufactured into vaſes, medallions, and other ornamental forms. The ſubſtance of which they form their mortars, and a variety of chemical utenſils, is extremely hard, and is not acted upon by acids.

The black and the yellow ware made by Meſſrs. Wedgewoods, of which the late Mr. Wedgewood was the inventor, poſſeſſes great elegance, and a very compact body. The black ware owes its colour to the preſence of oxyd of iron, and a ſmall portion of oxyd of mangaueſe. The yellow ware, which is ſimilar in texture, owes its colour to the preſence of a little iron alone. A great number of places furniſh natural products capable of aſſuming this yellow tint. The compactneſs of the body is effected by uſing leſs flint in the compoſition, and giving it more heat in the burning. This biſcuit is ſo compact that it does not require to be glazed, and this is what conſtitutes its great excellence. Its beauty is much greater in being deſtitute of the glaze or vitreous coating, which, when it is managed in the beſt way poſſible, is but a miſerable imitation of a poliſhed ſurface. That ſpecies of ware which, from its great hardneſs, has been called ſtone-ware, is not encouraged ſo much as it deſerves. It is employed for the moſt common, and the cheapeſt articles, when it ought to be uſed for all domeſtic pottery. Every other kind, excepting the true porcelain, is objectionable on account of its porous texture, and the lead contained in their glaze. Every ſpecies of clay capable of bearing a great heat, may be employed in the manufacture of ſtone-ware. Thoſe which contain much oxyd of iron cannot be employed, as they would be liable to ſoften, and even to melt in the heat required for glazing.

This manufacture is at preſent almoſt entirely confined to bottles, particularly thoſe uſed for ſoda water and artificial mineral waters, their texture being ſufficiently cloſe to hold gas compreſſed to ſeveral atmoſpheres.

The clay is prepared in the ſame way with that uſed in making the pottery already deſcribed. Indeed, there would be no difference in preparing the veſſels for the kiln, whether formed by throwing, preſſing, or caſting. It is ſimply in the burning and glazing that the difference conſiſts. In making the common articles, the veſſels are piled up in the kiln, and expoſed to the naked fire, without being defended by ſagars. It is on this account that they receive a much greater heat than the common earthen-ware. When the heat has arrived at its maximum, a quantity of common ſalt (muriate of ſoda) is thrown into the body of the kiln. The ſalt riſes in vapour, which ſpeedily envelopes the hot ware, and glazes it as completely as in any other way, if the heat be ſufficient. It is likely that the ſalt is decompoſed, the acid flying off, while the ſoda combines with the earths of the pottery, forming a vitreous coating. The ſmoke being in contact with the ware, gives it a browniſh colour. The fracture is cloſe and compact, and its ſtrength much greater than the common white ware. This pottery might be extended to a variety of other articles for culinary purpoſes, and with proper contrivance in the conſtruction of the kiln, articles might be made with as much taſte and elegance as any other.

When the Dorſetſhire clay is employed, and the ware defended from the ſmoke while burning, and at the time the ſalt is thrown in, the colour of the ware would be white, and the glaze tranſparent. When the clay is not ſufficiently white, it may be rendered ſo ſuperficially by dipping the dry ware, before it goes into the kiln, into a mixture of Cornwall clay and water in the ſtate of a thinniſh pulp. It is taken out, and turned about, as in glaze dipping, in order to ſpread the coating uniformly. The water is abſorbed by the dry ware leaving a coating of the white Cornwall clay upon the ſurface. A dip made with water and a fine powder of the Cornwall ſtone, would anſwer better than the latter, as it would more eaſily fuſe with the ſublimed ſalt. The whiteneſs of the Dutch tiles is produced in this way, as the body will be found of a dirty grey colour.

The moſt common and worſt kind of earthen-ware made in this country is formed of common clay uſed for bricks. The ware, after being rudely formed, is very ſlightly burnt, and afterwards glazed with a compoſition of galena (ſulphuret of lead), oxyd of manganeſe, and the clay of the ware. The glaze is of a dark colour, approaching to black. The lead in this ware is eaſily attacked by acids, and ſhould not be uſed where they are liable to be preſent. The ſame earthen-ware, unglazed, is uſed for garden pots, tiles, and tubes for draining land.

We ſhall conclude this article with ſome account of the methods of forming crucibles, retorts, and tubes of earthenware.

Theſe veſſels are required to poſſeſs two very eſſential qualities; firſt, they ſhould bear the naked fire without cracking; and, ſecondly, they ſhould bear the heat of the hotteſt furnaces without fuſing. The retorts and the tubes ſhould at leaſt poſſeſs the firſt property, and require a greater cloſeneſs of body more than that required for crucibles.

The crucibles called Heſſian crucibles have held a high character, both on the continent and in this country, but they are not uſeful for all purpoſes. The Dutch crucibles, which contain plumbago, are well calculated to bear ſudden changes of temperature, but become very tender, and fuſe at a high temperature.

A ſimilar manufacture is carried on at Chelſea; the crucibles are quite as good as the Dutch ones, and of a much better form.

Very excellent crucibles are made of the Stourbridge clay, particularly for melting caſt-iron and ſteel. This clay is worked up with the powder of the broken pots, which has the effect of making the pots ſtand ſudden changes of temperature. It has been lately found, in the caſt-ſteel works at Sheffield, that the beſt crucibles for their purpoſe are formed of the Stourbridge clay, worked up with powdered coak of pitcoal. This enables the crucibles to bear ſudden changes of temperature, and at the ſame time to bear the greateſt heat of our beſt air-furnaces. The Corniſh clay might be uſed with pounded coak with ſimilar ſucceſs, and might perhaps be ſuperior to the Stourbridge clay for earthen retorts and tubes. None of theſe articles ſhould be very hard burnt, as they will, in conſequence, be more liable to crack with ſudden heat, and even in the regular way of bringing them up with the fire.

POTTERY, *Chineſe*. See PORCELAIN.

POTTERY, *The*, or *The Potteries*, in *Geography*, an extensive tract of country in the hundred of North Pyrehill, and county of Stafford, England, comprehends an area of about eight miles long and six broad, and is perhaps the most populous and busy of any district of similar extent in Great Britain. It derived its name from being almost exclusively appropriated to extensive manufactories of earthenware, for which its situation and peculiar characteristics are excellently adapted. The soil presents, in almost every part, a great variety of clays; covering rich and productive strata of coal, which lying in general near the surface, are wrought at a comparatively small expence. These strata are usually divided by veins of clays, most of which form excellent fire-bricks for constructing potter's kilns and sagars, to burn the ware in. Finer clays also are plentiful in many places; of which in former times the bodies of the wares themselves were wholly manufactured. To these advantages, joined to the inaptitude of the soil for husbandry purposes, this district is doubtless indebted for its selection as the scite of its present staple manufactories. When this originally occurred is utterly unknown, but the existence of some kind of earthenware manufactory can be traced at least two centuries back. Its principal seat at that period was the town of Burslem, which was called a butter pottery; that is, a manufactory of pots for the preservation of butter; and under that name it is marked in several old maps: but this establishment seems to have been, even so late as the year 1686, very inconsiderable, as Dr. Plot, in his "Natural History" of the county, says, that the sale of its products was chiefly "to the poor crate-men, who carried them *at their backs* over all the country." All the ware was then of a coarse yellow, red, black, and mottled kind. The common glaze was produced by lead ore finely powdered, and sprinkled upon the pieces of ware before firing; sometimes with the addition of manganese. Occasionally, when the potter wished "to shew the utmost of his skill," he employed, instead of lead ore, calcined lead itself, but still sprinkled it on, in the same rude manner.

The era of improvement commenced about the year 1690, when two ingenious Dutchmen, of the name of Elers, settled here, and introduced the practice of adding common salt to the clay when at its highest heat, in order to give it a superficial vitrification. The same individuals also introduced the manufacture of a new species of ware, in imitation of the unglazed red china of the East; and the clays here being suitable for the purpose, they succeeded wonderfully for a first attempt, so that many of their tea-pots are said to have sold as high as a guinea each. The next improvement was made in the substance of the ware itself by a Mr. Astbury, as tradition asserts, through this incident. Being on his way to London, he happened to have powdered flint recommended to him to cure some disorder in his horse's eyes, and accordingly a flint stone was thrown into the fire, to render it more easily pulverable, which changing to a pure white by the influence of the heat, the potter was struck with the idea, that his ware might be improved by an addition of the same material to the whitest clays. He tried the experiment with tobacco-pipe clay, and the event proved fully answerable to his expectation. Thus originated the *white* stone wares, which soon supplanted the coloured ones, and continued for many years the staple branch of pottery in this country.

It was, however, about the year 1760, that the most important improvements began to be made in the Staffordshire potteries, by the late Josias Wedgewood, esq. This gentleman not only improved the composition, forms, and colours of the old wares; but likewise invented, in 1763, a new species of ware, for which he obtained a patent, and which being honoured by her majesty's approbation and patronage, received the name of Queen's ware. Continuing his experimental researches, Mr. Wedgewood afterwards invented several other species of earthen-ware and porcelain, of which the principal are: 1. A *terra cotta;* resembling porphyry, granite, Egyptian pebble, and other beautiful stones of the siliceous or crystalline order. 2. *Basaltes*, or *black ware;* a black porcelain biscuit of nearly the same properties with the natural stone, receiving a high polish, resisting all the acids, and bearing without injury a very strong fire. 3. *White porcelain biscuit;* of a smooth wax-like appearance, of similar properties with the preceding. 4. *Jasper;* a white porcelain of exquisite beauty, possessing the general properties of basaltes; together with the singular one of receiving through its whole substance, from the admixture of metallic calces, the same colours which those calces give to glass or enamels in fusion; a property possessed by no porcelain of ancient or modern composition. 5. *Bamboo*, or cane-coloured biscuit porcelain, of the same nature as the white porcelain biscuit. And 6. A *porcelain biscuit* remarkable for great hardness, little inferior to that of agate; a property which, together with its resistance to the strongest acids, and its impenetrability to every known liquid, renders it well adapted for the formation of mortars, and many different kinds of chemical vessels. For some further account of this gentleman's discoveries; see WEDGEWOOD, JOSIAS.

The above six distinct species of ware, together with the queen's ware first noticed, have increased, by the industry and ingenuity of different manufacturers, and particularly by Mr. Wedgewood and his son, into an almost endless variety of forms for ornament and use. These, variously painted and embellished, constitute nearly the whole of the present fine earthen-wares and porcelains of English manufacture.

The number of persons who derive their support from the manufacturing part of the pottery business alone, including the wives and children of those employed in it, is computed to exceed 25,000 persons; and probably three times that number depend for bread on the labour it creates, particularly in the collieries, in procuring the raw material from several distant parts of the kingdom, and in the inland navigation connected with the same, and of the manufactured product. The pottery district lies chiefly in the parishes of Burslem and Stoke; and, as happens in most manufacturing districts, it is remarkable for the great diversity of opinion which prevails among its inhabitants on the subject of religion. Of the various sects, however, the Methodists claim a decided superiority, in point of number, over all the others. The principal towns and hamlets comprised within the limits of The Pottery, are Stoke, Hanley, Shelton, Golden-Hill, New-Field, Smith-Field, Tunstall, Long-Port, Burslem, Cobridge, Etruria, Lane-End, Lower-Lane, and Lane-Delft.

Stoke, or, as it is commonly called, Stoke-upon-Trent, has recently been constituted a market-town; and has a market-house furnished with all the accommodations requisite for its object. The church is an ancient and spacious edifice, in the later Norman style of architecture. Like most other parts of The Pottery, this town has increased in size and importance since the Staffordshire canal was cut. It contains many handsome buildings; and from its proximity to a wharf upon the canal, is most conveniently situated for trade. At this place the first steam-engine for grinding burnt flints, erected in this country, was established about twenty years ago by a gentleman named Spode. The earthen-ware manufactories here are numerous; and many of them are upon

an extenſive ſcale. Cloſe to the town the canal is carried over the river Trent, by means of an aqueduct conſtructed entirely of brick.

Hanley is ſituated about two miles northward from Newcaſtle-under-Line. This town alſo has a weekly market on Monday; and is diſtinguiſhed for the neatneſs and regularity of its ſtreets, and the elegance of many of the houſes which compoſe them. Here is a church, which was founded in 1788; alſo ſeveral chapels and meeting-houſes appropriated to the worſhip of diſſenters.

Shelton is a very extenſive place, but has not hitherto been conſtituted a market-town. It is particularly deſerving of notice on account of its china manufacture, which rivals the famed porcelain of the Eaſt. The ingenious Mr Champion of Briſtol, who diſcovered the art of making this ſpecies of ware, expended an ample fortune in various trials, but having ſucceeded ultimately in bringing it to perfection, he obtained a patent for it, which he ſold to the firm of Hollins, Warburton, and Co. As the canal paſſes Shelton, there are a public wharf and ſtore-houſes upon it, for the landing and ſafety of goods.

Golden-Hill, from its name, one would ſuppoſe to be a conſiderable and even ſplendid place; but on compariſon it is found to be the leaſt ſo of any in The Pottery. Its valuable mines of coal, however, make ample amends for its other deficiencies, and from the richneſs of thoſe mines it derived its name. At the upper end of this village is Green-lane, which commands a moſt unbounded and beautiful proſpect, on the one ſide over the greater part of Cheſhire, and on the other over the whole extent of The Pottery, and a large portion of the country adjoining.

New-Field is well ſituated for manufacturing purpoſes, from the great plenty of coal in its immediate vicinity, but as it belongs wholly to one perſon, who has a handſome ſeat cloſe to the village, there are fewer pottery eſtabliſhments here than would otherwiſe have been the caſe.

Smith-Field, like *New-Field,* is well ſituated for carrying on pottery manufactories, having ſeveral ſtrata of coal and clay cloſe adjoining; but ſimilar reaſons prevent their being increaſed and extended in the ſame proportion as in ſome of the other villages in the diſtrict.

Tunſtall, including its environs, is the pleaſanteſt village in The Pottery. It ſtands upon high ground, at the diſtance of four miles northward from Newcaſtle, and appears to have been formerly the ſcite of a religious inſtitution, of which ſome remains were viſible about the middle of the laſt century. Theſe, however, are now completely gone; and a neat chapel has been erected on or near the ſpot which it occupied. The principal works here are for bricks and tiles; the clay being of a very ſuperior kind for the manufacture of ſuch articles. The tiles made from it, indeed, by good management take a blue colour, which renders them almoſt as fit for roofing as ſlates.

Long-Port is ſituated in a valley between Newcaſtle and Burſlem. It has many good buildings in it, and ſeveral large and extenſive manufactories; but owing to its low poſition, it is at times diſagreeable from the ſmoke hanging upon it longer than it commonly does upon higher ground. The Staffordſhire canal paſſes this village, and has a public wharf upon it.

Burſlem, as already ſtated, is the moſt ancient town in the whole Pottery, and was undoubtedly the firſt ſeat of the earthen-ware manufacture in Staffordſhire, and perhaps in Great Britain. Plot, in his "Natural Hiſtory" of the county, makes particular mention of the potteries at this place, and points them out as the greateſt of the kind then known. This author, likewiſe gives an ample detail of the proceſs of making the ware in his days. Burſlem has two markets weekly on Monday and Saturday, but that on Monday is by far the moſt conſiderable. Here are alſo regular annual fairs, eſtabliſhed about twenty years ago, for the ſale of cattle. The church, which is parochial, is an ancient ſtructure, but has been much altered, enlarged, and modernized within the laſt twenty years. The Methodiſts have two chapels in Burſlem, and are very numerous. In this town is a great variety of other ſectarians.

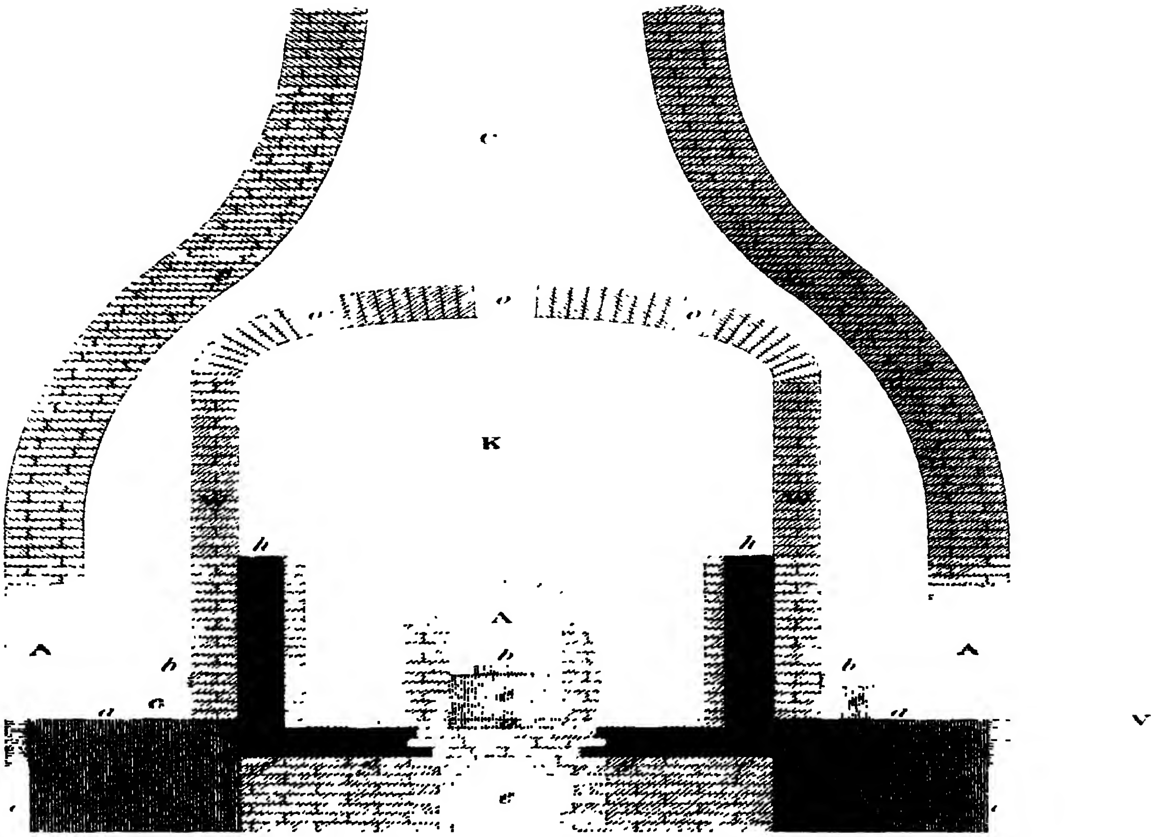
Cobridge, which is ſituated partly in the pariſh of Burſlem, and partly in that of Stoke, is a very large and populous village, and poſſeſſes ſpacious manufactories "of the ſtaple articles of the country earthen-ware in it."

Etruria is a large village, in which is a ſeat belonging to Joſias Wedgewood, eſq., who has the moſt extenſive manufactory here of any in The Pottery. The name Etruria was beſtowed upon it by the father of the preſent proprietor, whoſe inventions and diſcoveries have not only, as before mentioned, advanced his own particular art, but have contributed in a high degree to the enlargement of natural knowledge in general.

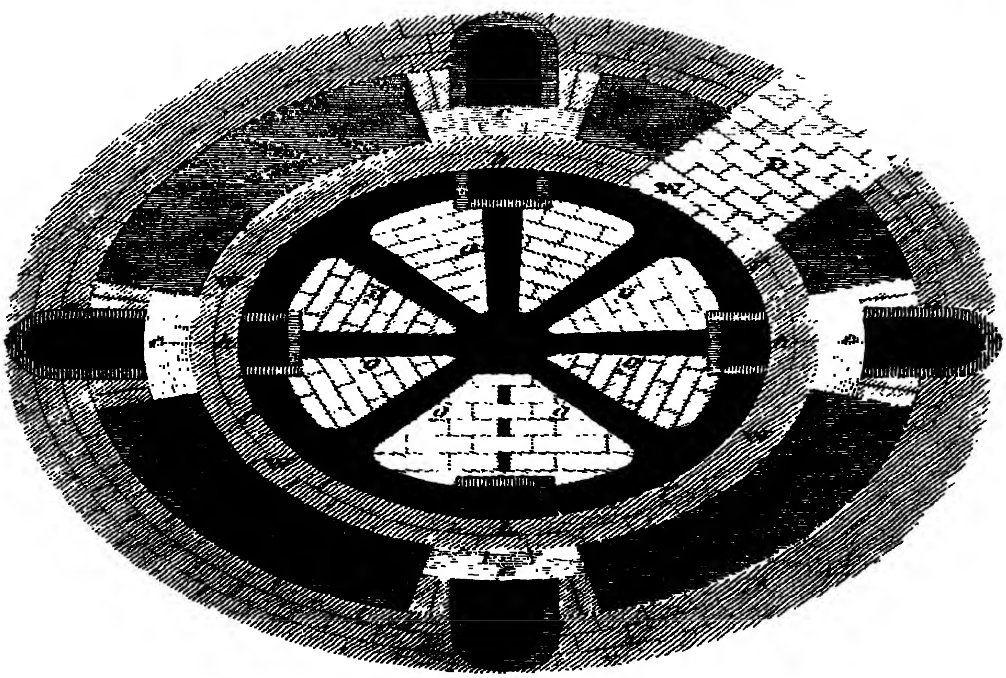
Lane-End, Lower-Lane, and *Lane-Delft* adjoin, and conclude The Pottery on its eaſtern boundary. The firſt mentioned of theſe townſhips is by far the moſt conſiderable of the three, containing, according to the returns for 1811, 1097 houſes, and 4930 inhabitants. Here are a chapel of eaſe to Stoke, a Methodiſt chapel, and ſeveral meeting-houſes for diſſenters. Among the leſs important places in this diſtrict, where manufactories of earthen-ware are eſtabliſhed, are New-Chapel, Wolſtanton, Redſtreet, and Norton, which are the moſt conſiderable. A Deſcription of the Country from thirty to forty Miles round Mancheſter, by J. Aikin, M.D., 4to. Shaw's Hiſtory, &c. of Staffordſhire, fol. vol. 1.

POTTERY

Vertical Section.



Horizontal Section



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Press

PRESS, a machine of moſt extenſive uſe in the mechanic arts, for ſqueezing or compreſſing any ſubſtance very cloſe, and alſo to retain the matter under the preſſure as long as may be required.

All preſſes conſiſt of the following parts: 1ſt, two flat, ſmooth tables of wood or metal, between which the ſubſtances to be preſſed are placed; 2dly, the frame, or cheeks of wood or metal, which unite and retain the two together; and 3dly, the mechanical power, by which the preſſure is effected. This is generally a ſcrew, or two ſcrews, turned by a long lever, or by wheelwork. At other times a rack is employed, and moved by a pinion turned by wheelwork, to give it a great power. Some preſſes uſed for expreſſing of oils are actuated by a wedge driven by a hammer or ſtamper, (ſee OIL-*Mill*,) and in others, the preſſure is produced by means of a powerful lever, and retained by a rack and click. Of late years the hydroſtatic preſs has been produced, acting by the preſſure of water or other fluids in cylinders. We ſhall now ſpeak of the different kinds of preſſes.

Screw-preſſes are thoſe in which the preſſure is cauſed by means of one or more ſcrews; the moſt common have a ſingle ſcrew, formed either of wood or iron, which at its lower end has a globe-head, with four holes through it, for the reception of the end of the lever employed to turn the ſcrew; the thread of the ſcrew is fitted through a nut, fixed faſt in the head of the wood, or iron frame of the preſs. This frame conſiſts of a lower bed, or horizontal piece, on which the matters to be preſſed are laid, two upright cheeks being firmly united with it, and ſupporting the head, or upper horizontal piece of the preſs, in which the nut of the ſcrew is fixed; the lower point of the ſcrew is united with the follower, or moving bed of the preſs, and this reſts upon the ſubſtances to be preſſed, and the power of the ſcrew forces it down upon it.

A drawing of this preſs, with its lever, and alſo a windlaſs to work it with immenſe power, will be found in *Plate* XI. *Agriculture*, as applied to expreſs the juice of fruit for cider. The ſame kind is alſo employed for expreſſing ſome vegetable oils, but generally with iron framing, becauſe of the great ſtrength required; for packing cloth, paper, and other goods; alſo in the paper-mills, for flattening and rendering paper ſolid; and in the manufacture of woollen cloth, for glazing and ſetting a finiſh upon the article in its laſt ſtage.

Two elevations of a very good ſcrew-preſs for a paper-mill are given in *figs.* 6 and 7 of *Plate* II. *Paper-Mill.* A A is the bed, formed of an immenſe beam of oak; and each of the cheeks, B, conſiſts of a long iron bar *b b*, (*fig.* 7.), the ends of which are welded together, ſo that it forms a long link, one end of which receives the end of the bed A, and the other the end of a maſſive caſt-iron croſs bar or head D, through which the ſcrew, E, is received, and its nut fixed faſt therein. The open ſpaces of the long links or cheeks, *b*, *b*, are filled up by rails of wood, C, which ſupport the weight of parts of the preſs when it is not in action, but theſe bear nothing, when the preſs has any articles under preſſure in it; theſe articles are laid at H, on the bed, and the follower, G, is preſſed upon them by the ſcrew, when it is turned by a long lever put through the holes in the ſcrew-head F. The ſcrews employed for paper preſſes are generally formed with ſuch coarſe threads, and ſo rapid a ſpiral, that the elaſticity of the paper is ſufficient to force it to run back. To theſe a ratchet-wheel, *a*, is fixed, and a click, *e*, (*fig.* 8.) is applied to its teeth: to prevent its return, the click is ſupported on a bar *b d*, which moves on a centre at B, but the other end is retained by a catch or lever *f g*. When the preſs is to be relieved, the end, *f*, of the catch is driven back; this relieves the bar *d b*, and the click no longer detaining the ratchet-wheel, the ſcrew runs back.

The ſcrews for preſſes were formerly made of wood, with ſharp threads, that is, the worm of the ſcrew, if cut acroſs, would make a triangular ſection, the baſe thereof abutting upon the cylinder of the ſcrew. In this method it was neceſſary to have the threads very coarſe, to give them ſufficient ſtrength, and then the power of the ſcrew was not ſo great as in the modern preſſes, where the ſcrews are made of iron, and their threads need not be above one-third or fourth the diſtance aſunder, to have the ſame ſtrength.

Another advantage of the iron ſcrew is, that the friction is ſo much diminiſhed, that a far greater preſſure can be obtained by the ſame exertion of the people who work it. The frames of the modern preſſes are alſo made of iron, wood being found incapable of reſiſting the ſtrain of a ſevere preſſure, for any conſiderable length of time; as all the fibres, even of the hardeſt oak, become ſeparated into ribbands, and then break one at a time, till the whole beam fails.

Another kind of ſcrew-preſs conſiſts of two ſcrews, which are immoveably fixed in the lower board or bed, and paſſing through holes in the upper board, have nuts upon them, which being turned by a lever, draw the two boards together, and exert a preſſure upon any thing placed between them. Sometimes the ſcrews paſs through the upper board, and are tapped into the lower one; then the ſcrews themſelves are turned round by a lever put through their heads, inſtead of turning the nuts. Preſſes of this kind, when accurately made, have a communication of wheelwork from one ſcrew to the other, ſo that both ſhall turn round together, and cauſe the two boards of the preſs to advance parallel to each other.

A very ingenious and uſeful packing preſs, invented by Mr. John Peek, was, in 1798, rewarded by the Society of Arts. This machine conſiſts of two very ſtrong horizontal beams, one at the bottom for the bed, and the other at the top of the preſs. Theſe are united by two iron ſcrews, which ſtand in a vertical poſition, and therefore ſerve as cheeks to the preſs. The follower of this preſs is a very ſtrong horizontal beam, having two nuts fitted into it at its ends. Theſe nuts act upon the threads of the two vertical ſcrews; and, therefore, it is plain when they are turned round, the follower will riſe and fall upon them. The nuts are ſo fitted into the follower, as to admit of a circular motion round the ſcrews, but are not permitted to riſe or fall without the follower, becauſe they have a circular ring or projection in the middle of their length, which is fitted into a proper receptacle in the wood-work. To give them motion, the edges of the circular rings are cut into cogs or teeth, and are turned by means of an endleſs ſcrew for each, ſituated at the oppoſite ends of a horizontal ſpindle, which revolves in bearings attached to the follower of the preſs. The ſpindle has a winch at each end, by turning which, the two endleſs ſcrews act upon the wheels or teeth of the nuts; and by thus cauſing them to turn round with equal velocities, raiſes or depreſſes the follower, always parallel to itſelf, and alſo to the head and bottom bed.

The great utility of this preſs conſiſts in its being capable of packing two ſets of bales at once; thus anſwering the

purpose of two presses, and with more expedition. It is placed upon the floor of the warehouse in which the packing is to be performed, and behind it a stage is erected, just half the height of the whole press; then one set of the bales are made up on the floor, and the other upon the stage. Suppose the follower raised up above the level of the stage, a bale of goods is placed on the lower bed, and by turning the winches, the follower is forced down upon it, till it is sufficiently pressed: now, while the men below are tying and making the bale fast, the people on the stage place a bale upon the follower; and it is plain, that when the follower is raised up to relieve the lower package, the upper bale will be compressed between the follower and the head of the press; and while this is making fast, the workmen below get another bale of goods loaded in. By this means no time is ever lost in screwing up or opening the press; for it performs work both ways, which is a matter of no small importance in large works, such as the East India Company's warehouses, where such a great number of people are employed in packing.

In the Philosophical Transactions for 1781 is an account of a double screw, applied to a press, by Mr. W. Hunter. To explain this, we must suppose a single screw-press of the ordinary form, such as shewn in *Plate* XI. *Agriculture*, or *Plate* II. *Paper-Mill;* but the lower end of the screw, which rests upon the follower or presser, has a second screw of finer thread cut upon it. This thread is received into a nut or barrel, which rests upon the presser. The nut is at liberty to turn round freely upon the presser, except when it is required to be stationary; and then, by a key, it can be fixed fast to it. In like manner, the nut or barrel can, at pleasure, be fixed fast to the lower screw by a key put through a hole in both; and in this state they will of course turn round together. As the nut and lower screw take up some room, the screw is turned by arms fixed in a head, formed on the upper end of it, above the press. In the operation of this press, the nut or barrel is pinned fast to the lower screw by the key; and the screw being turned by the arms at top, the nut is carried round with it, and the effect is exactly the same as an ordinary screw-press. But having by this means given as great a pressure as the single screw is capable of producing, the cross key which unites the lower screw to the barrel is removed, and is put in such a position, that it unites the barrel to the presser, so as to prevent its turning round upon it. The effect of the press now becomes compound, and while the whole screw is carried downwards by the revolution of the great screw, the fine screw at the bottom of it screws down into the barrel or nut, which is attached to the presser; which is, therefore, carried down a quantity only equal to the difference of the thread of the two screws; and if these are made very nearly alike, the descent produced by the difference between them will be exceedingly small, and the power exerted upon the articles under pressure will be in proportion to it. Indeed the effect would be the same, as if a single screw had been employed, having its threads so fine or close together, that the difference between thread and thread is only equal to the difference between the measures of the threads of the two screws.

For example: Suppose it was required to produce a strong pressure, with a screw of ten threads in an inch, it is evident that the metallic protuberance, or helix of the screw, could not be quite so thick as one-twentieth of an inch, and could not, therefore, withstand any considerable force. By the present construction, we may have the thread as strong as can be desired. Thus, if the slightest be a quarter of an inch, the finest screw must have two turns in the inch, and the coarsest two turns in one inch and one-tenth; or, in other words, it would pass over the same space in ten turns, that the other screw would in eleven.

Upon the invention of the double screw Mr. Nicholson remarks, that from the extreme precision of a simple screw, if commonly well made, it may seem scarcely necessary to use this contrivance in the measurement of small quantities. The finest screws usually to be met with do not exceed 100 threads in the inch, and few have been made finer than of 200 threads in that space. Let us consider by what threads, of usual, or even coarse numbers, we could have a difference *per* turn of above one-thousandth of an inch, and we shall find that the difference between a thread of 32 and one of 33 in the inch, is the 1056th part of an inch; so likewise, the difference between the 60th and 61st parts of an inch is the 3660th part.

The *Hydrostatic* or *Water Press* has, for a great number of purposes, superseded the use of the screw-press, over which it possesses great advantages, in all cases where a strong pressure is required. This machine was invented by Mr. Joseph Bramah, and its principle has been explained in our article MACHINERY. (See vol. xxi.) In plate *Press* we have given drawings of one of them, *figs*. 1 and 2 being elevations, taken in opposite directions; A A B *c c* is the frame, consisting of a piece of cast iron, *c c*, (see also *fig*. 3.), and a top piece of cast iron, B, (see also *fig*. 4.), the two being united by the wrought iron bolts A, A, which must have sufficient strength to resist the whole force of the press, the pressure being produced between the under surface of B, and the upper surface of an iron table or follower, E; F is a strong metallic cylinder, in which the rammer or piston, D, moves. To the upper part of this piston, the iron table, E, is fixed, by the motion of which upwards, the pressure is communicated to the articles placed upon it; L represents a cistern containing water; within this cistern is fixed a small forcing or injecting pump, of which *h* is the piston rod, and H the lever by which it is worked, a contrivance being introduced for keeping the piston rod vertical during the working: it consists of a guide, formed at the top, of the same standard, K, which supports the fulcrum or centre pin, *e*, of the lever H; the rod *g*, which is part of the piston rod, slides through the socket; the part, *f*, of the rod is made open, to admit the lever to pass through it, a link being applied to unite the lever to the rod; I is a counterbalance for the weight of the lever. *Fig*. 5. is a section of the pump, on a larger scale, to shew its interior structure, *h* representing the lower extremity of the piston rod; it is surrounded by a collar of leather, *s*, which is retained in its place by a tube, or perforated screw, *r*, which admits the passage of the piston rod *h*, but which screws the two-cupped leathers with the metal ring, which is interposed between them, close down to a shoulder, in the body of the injecting pump, and thus renders the junction between the injecting piston *h*, and its cylinder, water-tight: the upper part of the screw, *r*, is excavated, to form a receptacle for oil; M M is the barrel, or chamber of the pump, in which the piston rod does not fit; but the collar of leather *s*, closely embracing the rod, will have the same effect of enlarging or diminishing the capacity of the chamber when the rod is moved up and down. In the bottom of the chamber is a suction valve, N, which allows the water to enter into the barrel from the cistern, but will not permit it to return in the same direction; it is fitted into the upper part of a tube, N, which is screwed into the lower end of the barrel: the valve itself

consists of a metallic rod, at one end of which there is a knob turned conical next the stem, so as accurately to fit the conical face of the hole into which it is put; the tail is filed on one side, so that it does not entirely fill the cylindrical hole which it occupies, by which means a passage is afforded for water when the head of the valve is raised. A valve of a similar nature is placed at *t*, in the upper part of the pump, and being in the passage which conveys the water from the pump, and through the copper pipe, *b*, to the cylinder, F, it allows the water to pass from the pump to the cylinder, and prevents its returning. At *k*, *fig.* 5, is a safety-valve, which is loaded by a steelyard and weight, as shewn at *k*, *fig.* 1: this keeps the valve shut in the ordinary course of working; but if the pressure should become so great as to endanger the bursting of the pipes, the valve rises, and the water escapes. At *i* is a screw plug, or valve, at which the water is discharged, when the press is to be relieved. When screwed tight, its conical end or point is forced into a corresponding socket, and prevents the escape of the water; but on turning the screw back, the water is permitted to flow back into the cistern. The real situation of this discharging valve is shewn in *fig.* 1, at *i*. The cylinder, D, is surrounded by a collar of leather at *o o*; the leather is formed as shewn in *fig.* 7, being turned up to form a double cup, so that it resembles the cuff of a coat sleeve. When in its place it is kept distended by the copper ring, *p*, entering the circular channel, or fold, of the leather. This ring has a lodgment in a recess formed within the cylinder F. The leather is kept down by a brass or bell-metal ring, *m*, which is received into a recess formed round withinside the cylinder, as shewn in *fig.* 5. The interior aperture of this ring is adapted to receive the cylinder D, and thus the leather becomes confined in a cell, with the edge of the interior fold applied to the cylinder D, whilst the edge of the outer fold is in contact with the interior surface of the cylinder F. In this situation the pressure of the water, acting between the folds of the leather, forces its edges into close contact with both, and makes a tight fitting round the cylinder, and as the pressure is increased the leather is applied more closely, so as to prevent leakage under any circumstances. The metal ring, *m*, is truly turned in the lathe, and the cavity or cell formed for its reception; then to get it into its place, it is divided by a saw into five segments, as shewn in *fig.* 6. Three of the lines at which it is divided point to the centre, but the other two are parallel to each other, and the ring is put into its place (after the leather and copper rings are introduced), by putting in the four segments separately, and the one with parallel sides is put in last. The cylinder, D, is then put down in its place, and ready for action. This plan of a divided ring was first used by Mr. Peter Kier, who, since the expiration of Mr. Bramah's patent, has made several hydrostatic presses. In the original construction, the ring or head of the cylinder, which kept down the leather cup, was held down in its place by several screw bolts, but as these had to bear a greater force than the whole power of the press, they were frequently torn out, or strained, so as to cause leakage. The upper part of the cylinder above the ring, *m*, is filled with tow, or other soft packing, impregnated with sweet oil, which is confined by a thin plate or ring. This packing serves at once to supply the cylinder with oil, and to prevent the admission of any substance which might injure the surface of the piston.

The pipe, *b*, is made of copper, and its joints are made as shewn in *fig.* 5. The end of the pipe has a projecting piece soldered or screwed upon it, and this fits into a cavity formed in the metal of the pump or cylinder, and it is forcibly pressed into its seat by a perforated screw *w*, which screws into the cavity. The joints are rendered tight by a leather ring or washer, interposed between the end of the pipe and the bottom of the cavity in the cylinder or pump.

The hydrostatic press is not liable to get out of order, but if any extraneous matter attaches itself to either of the valves, their action will necessarily be suspended till it be removed; for this purpose the valves can be taken out. The valve at *t* has a screw plug, *g*, fitted over it, and this regulates the ascent of the valve, or by unscrewing the plug the valve can be taken out. To get access to the lower valve, the lower piece, N, of the pump must be unscrewed. The discharging valve, *i*, may also be examined by withdrawing its screw.

The operation of this press may be very readily comprehended, by supposing the pump, cylinder, and connecting pipe *b*, to be filled with water, and that an adequate supply of water is contained in the cistern L. When the handle of the lever, H, is raised, it brings up the piston *h*, which would leave a vacuum beneath, if the atmosphere did not force the water through the lower, or suction valve, of the pump. The lever being then pressed down, the piston rod, by descending, diminishes the capacity of the pump; this causes the lower valve to shut, and forces the water through the valve *t*, whence it passes, by the pipe *b*, into the cavity of the great cylinder F, and raises the piston D, and pressing-table E, together with its load, a distance proportioned to the quantity of fluid injected. On the subsequent rise of the piston of the pump, the descent of the upper valve prevents the return of the water, and consequently the fall of the cylinder D. A repetition of the same process injects more water, and the pressure may, in this manner, be carried to a great extent. When it is proposed to relieve the action of the press, the discharge valve, *i*, must be opened by turning the screw back; the water then escapes out of the press into the cistern L, and consequently the table E, and the cylinder D, descend by their own weight, restoring the engine to its original situation.

The mechanical effect of the hydrostatic press will admit of an easy calculation. For it is known, that if there be a mutual communication between two columns of any fluid, whatever pressure or effort may be exerted on the one, will be transmitted to the other in a ratio proportional to the respective area of each column, consequently the proportion of the area of the injecting pump to that of the cylinder constitutes the hydrostatic power of the press, and the mechanical effort exerted on the injecting pump is transmitted to the cylinder D, by the intervention of the fluid, in a ratio proportional to their comparative areas.

If the diameter of the piston, *h*, be one quarter of an inch, and that of D one inch, that is to say, four quarters of an inch, one pound lodged upon the piston rod, *g*, will be in equilibrio with sixteen pounds lodged upon the table E, the weights of the parts of the engine attached to, and moving with each piston, being respectively included. And if the length of the lever, *e* H, be fifteen inches, and the distance between the centres of motion, *e f*, of their action upon the piston rod two inches, one pound at the end of H will gain an advantage of $7\frac{1}{2}$ times, when compared with that at *g*. Instead, therefore, of sixteen pounds, upon the table G, being equal in effect to counterpoise this last action, there will be required upwards of 120 pounds. But a man in this action of pumping, by a downward pressure, can, without difficulty, apply his whole weight, and with great ease one-third, or one-fourth, of his weight, suppose 50 pounds. In this case the pressure will be equivalent to 50 times 120 pounds, or 6000 pounds, that is to say, nearly three tons.

To compare this engine with a ſcrew in theory, we muſt enquire what fineneſs of thread, and length of lever, would afford a purchaſe of 120 to 1. Let us ſuppoſe the thread of a ſcrew, ſubſtituted in the place of the cylinder D, to be one-tenth of an inch thick, the diſtance from the top of one thread to the top of the next, will in this caſe be one-fifth of an inch. This is the ſpace through which the weight muſt riſe in one revolution of the ſcrew; the power muſt, therefore, move through 120 times that ſpace, namely, twenty-four inches. A lever or radius four inches long will deſcribe a circle ſomewhat larger than this, and conſequently ſuch an engine would, in theory, be equal in power to the hydroſtatic engine we have been deſcribing.

But when the ſubject is viewed practically, the difference between the two machines appears to be very remarkable. All practical men know how very large a part of the force, operating by means of engines, is employed in overcoming friction. Every one is aware of the extreme friction between ſolids, and the very ſlight friction which takes place between the parts of fluids. This is ſeen in the common expedient of oiling the pivots of wheels, and in the very gradual decay of motion in fluid bodies, while ſolids moving upon each other ſtop at once as ſoon as the force is diminiſhed to a certain degree. The ſcrew is an organ peculiarly liable to friction, and this friction is always much greater than the whole of the re-acting force, for there are few inſtances where a ſcrew will return from extreme preſſure, when the agency upon the lever is withdrawn. It is alſo to be conſidered, that the whole force of the weight or reſiſtance acts directly upon the face of the thread of the ſcrew, at the place where the motion is required to take place. It has not been aſcertained in what degree this reſiſtance or friction increaſes with the weight. In lighter actions the ſimple ratio has been inferred, but under more ſevere preſſures, the two metallic faces exclude the greater part of the half fluid matter between them, and appear, by the magnitude of their reſiſtance, to be attached to each other by a proceſs of the nature of coheſive attraction.

Mr. Nicholſon, in his Journal, relates the following experiments, which he made with one of Mr. Bramah's ſmall preſſes, which he makes for the purpoſe of copying letters, or writings, in the manner of Mr. Watt (ſee Copying); it had the ſame parts which we have deſcribed, but the frame made of wood. When employed to preſs papers, the force applied to the lever of the injecting pump was ſo ſlight, that the inſtrument required no faſtening to the table on which it ſtood; but the effect of the upper bar, B, which was of wood, three inches and a half thick, was ſuch, as bended it out of a ſtraight line upwards of a quarter of an inch, and it appeared that it might have eaſily been broken by continuing the preſſure. With a ſcrew-preſs, the ſcrew of which was iron, and nearly of the dimenſions above mentioned, excepting that the lever was twelve inches long inſtead of four inches, and the action on the lever upwards of two hundred weight, applied with a jerk, the effect was nearly the ſame: he eſtimated the advantage to be very much in favour of the hydroſtatic preſs.

In another preſs of this kind, the diameter of the great piſton was four inches, and of the ſmaller three-eighths of an inch, and the advantage given by the lever or handle was twelve to one. Above the piſton, D, of the great cylinder, was applied a long lever, at one end of which was an axis, and at the other end a large ſcale to hold weights; it contained twenty hundred weight. The diſtance between the axis of motion of this lever, and the part where it acted on the piſton, was ſix inches; and the diſtance from the ſame axis to the extremity where the ſcale was hung, was one hundred and twenty-ſix inches. Every hundred weight in the ſcale conſequently preſſed upon the piſton with a force equal to twenty-one hundred weight, whence the whole preſſure was twenty-one tons. It was eaſy to work the lever briſkly with one hand, and each ſtroke raiſed the ſcale nearly one-third of an inch. Forty-ſeven pounds, hung at the end of the lever, carried it down with a moderate ſwiftneſs of working; but a weight of only forty-three pounds remained in equilibrio, and did not deſcend. Now as the true weight in theory was thirty-two pounds, as deduced from the dimenſion of the parts in the manner already done, with regard to the ſmall preſs it follows, that leſs than one-third of the actual power was employed to give velocity, and overcome all friction.

It may be remarked, that the principal frictions in theſe preſſes muſt be at the circumference of the piſtons, and that theſe do not increaſe in the ſimple, but in leſs than the ſub-duplicate ratio of the power. For if the diameter of the great cylinder were double, every thing elſe remaining unchanged, the ſurface of its piſton, and conſequently the power, would be quadrupled, but the friction would be only doubled, and that merely at the leathering of the greater piſton D.

As the preſſure, in the experiment laſt mentioned, amounted to forty-ſeven thouſand and forty pounds upon the great piſton, of four inches diameter, and ſixteen circular inches ſurface, it amounted to two thouſand nine hundred and forty upon each round inch; but the medium preſſure of the atmoſphere on a round inch is nearly twelve pounds, conſequently the action was equal to two hundred and forty-five atmoſpheres, and as each of theſe correſponds with a column of thirty-four feet of freſh water, at a medium the water in the cylinder was preſſed in the ſame manner, as if the whole column had been eight thouſand three hundred and thirty feet, or one mile and two-thirds perpendicular height.

Large preſſes of this conſtruction are generally made with two pumps, of one inch and a quarter bore, and a cylinder of ſeven inches. Theſe have been uſed in preſſing hay and cotton for package, and are very effective in producing a greater condenſation on the material, with a much leſs application of moving power, and conſumption of time.

Presses *uſed for expreſſing of liquors*, are of various kinds; ſome, in moſt reſpects, the ſame with the common preſſes, excepting that the under plank is perforated with a great number of holes, to let the juice expreſſed run through into a tub, or receiver, underneath.

Others have only one ſcrew, or arbor, which paſſes through the middle of the moveable plank, which is made to deſcend into a kind of ſquare box, full of holes on all ſides; through which the juices flow, in proportion as the arbor is turned; by means of a little lever applied thereto.

Press *uſed by joiners* to keep cloſe the pieces they have glued, eſpecially pannels, &c. of wainſcot, is very ſimple, conſiſting of four members; *viz.* two ſcrews, and two pieces of wood, four or five inches ſquare, and two or three feet long; of which the holes at the two ends ſerve for nuts to two ſcrews.

Press *uſed by inlayers* reſembles the joiners' preſs, except that the pieces of wood are thicker, and that only one of them is moveable; the other, which is in form of a treſſel, being ſuſtained by two legs, or pillars, jointed into it at each end.

This preſs ſerves them for ſawing and cleaving the pieces of wood required in marquetry, or inlaid work.

Press, *Founders'*, is a ſtrong, ſquare frame, conſiſting of four pieces of wood, firmly joined together with tenons, &c.

This preſs is of various ſizes, according to the ſizes of the moulds; two of them are required to each mould, at the two extremities of which they are placed; ſo as that, by driving wooden wedges between the mould and the ſides of the preſſes, the two parts of the mould, in which the metal is to be run, may be preſſed cloſe together.

Press, *Printing*. See Printing *Preſs*.

Press, *Meſſenger of the*. See Messenger.

Press, *Auditors of the*. See Auditors.

Press, *Rolling*, is a machine for the taking off prints from copper-plates.

It is much leſs complex than that of the letter-printers.

See its deſcription and uſe under the article *Rolling-preſs* Printing.

Press, in *Coining*, is one of the machines uſed in ſtriking of money; differing from the balance, in that it has only one iron bar to give it motion, and preſs the moulds, or coins; is not charged with lead at its extreme, nor drawn by cordage. See Coinage.

Press, *Binders cutting*, is a machine uſed equally by book-binders, ſtationers, and paſteboard-makers; conſiſting of two large pieces of wood, in form of cheeks, connected by two ſtrong wooden ſcrews; which being turned by an iron bar, draw together, or ſet aſunder, the cheeks, as much as is neceſſary, for the putting in the books, or paper, to be cut.

The cheeks are placed lengthways on a wooden ſtand, in form of a cheſt, into which the cuttings fall. Aſide of the cheeks are two pieces of wood, of the ſame length with the ſcrews, ſerving to direct the cheeks, and prevent their opening unequally.

Upon the cheeks the plough moves, to which the cutting-knife is faſtened by a ſcrew; which has its key to diſmount it, on occaſion to be ſharpened.

The plough conſiſts of ſeveral parts; among the reſt, a wooden ſcrew, or worm, which catching within the nuts of the two feet, that ſuſtain it on the cheeks, brings the knife to the book, or paper, which is faſtened in the preſs between two boards. This ſcrew, which is pretty long, has two directories, which reſemble thoſe of the ſcrews of the preſs. To make the plough ſlide ſquare and even on the cheeks, ſo that the knife may make an equal paring, that foot of the plough where the knife is not fixed, ſlides in a kind of groove, faſtened along one of the cheeks. Laſtly, the knife is a piece of ſteel, ſix or ſeven inches long, flat, thin, and ſharp, terminating at one end in a point, like that of a ſword, and at the other in a ſquare form, which ſerves to faſten it to the plough. See Book-binding.

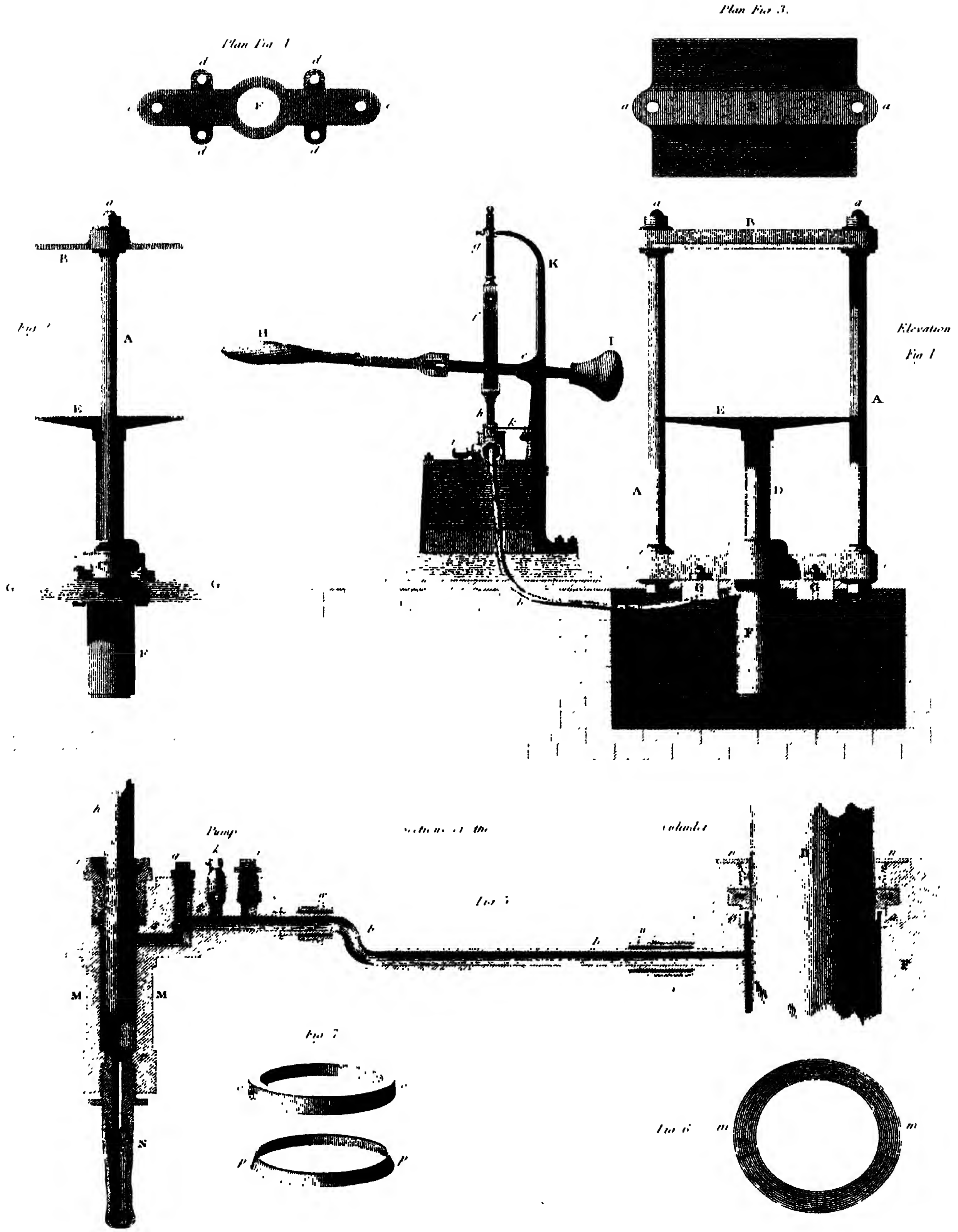
As the long knives uſed by us in the cutting of books or papers are apt to jump in the cutting thick books, the Dutch are ſaid to uſe circular knives with an edge all round; which not only cut more ſteadily, but laſt longer without grinding.

Press, in the *Woollen Manufactory*, is a large wooden machine, ſerving to preſs cloths, ſerges, rateens, &c. by which to render them ſmooth and even, and to give them a gloſs.

This machine conſiſts of ſeveral members; the principal of which are the cheeks, the nut, and the worm or ſcrew, accompanied with its bar; which ſerves to turn it round, and make it deſcend perpendicularly on the middle of a thick wooden plank, under which the ſtuffs to be preſſed are placed. The calender is alſo a kind of preſs, ſerving to preſs or calender linens, ſilks, &c.

RESS.

M



Pressure engine

Pressure *Engine* is an hydraulic machine, acting by the power of a descending column of water upon the piston of a cylinder, to give motion to pumps, for raising water from a different level. In the mountainous districts which so frequently contain rich mineral treasures, falls of water may be often obtained at a greater elevation than it is practicable to construct water-wheels of sufficient size to occupy the whole descent; and often the stream is too small to supply a wheel. In these situations the pressure engine is well adapted to produce the greatest effect from the fall, in working pumps, or other machines for draining the mines of water. The same principle can readily be extended to the raising of water for supplying towns, gentlemen's houses, &c.; and universally for raising water from any depth wherever a fall of water can be procured, particularly in those cases where the fall is great, that is, where it exceeds 30 or 40 feet. It will not only exceed all other known machines in effect, but in simplicity, and that whether the quantity of water that is to be applied is great or small.

Machines of this kind, invented by Mr. Denizart, are described in the Machines Approuvées par l'Academie for 1731, vol. v. and by Mr. Genssanes in 1741, vol. vii.; but the earliest which was put in execution in this country was by Mr. William Westgarth, who invented the proper expedients to obviate those difficulties which had before attended the practical execution of machines upon this principle in France; he erected a large one at a lead mine of sir Walter Blacket's, at Coal Cleugh, in Northumberland, in the year 1765. Mr. Westgarth's machine consisted of a cylinder, provided with a piston suspended by a chain from a beam or working lever, from the opposite end of which the rod of the pump, which was to raise the water, was suspended; the working cylinder was made the full height of the column of water which was employed to work the engine, and the working beam was, of course, placed above the top of it, whilst the chain and rod reached down into it; so that the piston itself acted in a chamber or barrel, nearly at the bottom of it; a trough, or cistern, at the top of the cylinder, was kept constantly supplied by the stream of water, and thus the whole height of the cylinder being filled with water, the pressure of its column always bore upon the piston. From the lower part of the cylinder was a passage to permit the water to escape from it, and likewise another passage by a pipe, communicating from the lower part of the cylinder, beneath the piston, to the upper part of the same above the piston. Both these passages were governed by a sliding valve of very ingenious structure, which opened and shut them alternately, but would not allow both to be open at one time. The sliding valve was actuated by an apparatus of levers, very similar to those used in the old steam-engines for opening the cocks; and the pump rods were so loaded as always to have a preponderance to draw the piston up when the pressure of the water upon it was removed or balanced. Suppose the piston at the top of its motion, by opening the passage from the bottom of the cylinder the water escapes from it, and relieves the lower side of the piston from the pressure of the water, whilst the whole column continues to press upon the upper side: in this situation the piston descends, drawing up a column of water in the pumps at the opposite end of the beam or lever, but on arriving at the bottom of the cylinder, the mechanism alters the sliding valve, and it closes the passage at which the water escapes from the cylinder, and at the same time opens the other in the pipe, which admitting the water from the upper into the lower part of the cylinder, it will press equally below the piston as above it, consequently the forces are balanced, and the counter-weight of the pump rods, at the opposite end of the beam, will draw up the piston to the top of its chamber, when the position of the sliding valve is again altered, and it closes the pipe, at the same time opening the passage for the water to escape; this makes another stroke, and thus the engine continues to work as long as the supply of water is kept up. The minutiæ of the machine are described in the Transactions of the Society of Arts, vol. i. but the ingenious Mr. Smeaton soon improved it very materially, by enclosing the top of the cylinder with a lid, through which the piston rod passes in a collar of leather, and the cylinder is then required to be no higher than convenient for the motion of the piston within it, the water being introduced to it by a pipe. The construction of Mr. Westgarth's sliding valve he preserved with very little alteration. In *Plate Pressure*, we have given drawings of a small engine which Mr. Smeaton erected in Yorkshire, at the seat of lord Irwin, in 1770, to raise a supply of water for the service of the house. *Figs.* 1 and 2 are elevations of the whole engine, and the other figures are enlarged sections of the sliding valve, which regulates the admission of the water into the working cylinder at proper intervals, to cause the motion.

The pipe, A, which supplies the engine with water is 1.7 of an inch bore; its perpendicular descent from its mouth or entry at the spring of supply is 54 feet; and its length 400 feet. The water is conveyed from the engine by a pipe, I, which has a fall or descent of twelve feet from the engine to the surface of the water in the pit or well into which it delivers; and it has a stop-cock, which regulates the discharge of the water. This descending column of 66 feet of water is employed in working a pump, D, which throws back part of the water to a reservoir by a pipe, *o*, in ascent about 900 feet in length, and 1.5 inch bore. The delivery of this pipe at the top of the reservoir is 80 feet above the engine, consequently 26 feet above the level of the head or spring of supply. The pipe, A, conducts the water to the pump, D, by one branch, and to the top of the cylinder, C, which works the engine, by the other. The cylinder, C, is of brass, truly bored, and furnished with a solid piston, whose rod, *b*, passes through a close stuffing-box in the cylinder lid, where a leather is packed round it so closely, that no water can leak by it; the upper end of the piston rod is keyed into a small box, which connects it with an iron rod, sliding through a guide, *c*, to make it move steadily. K is the working-beam, moving round a centre at L; it has an arch head at the outer end, which is a segment of a circle, struck from the centre L; the arch receives a chain, by which the piston-rod, *b*, is suspended, and therefore has a vertical motion. E is the pump-rod, jointed to the beam, and moving up and down with it; the forcer of the pump, D, is fixed to it at the lower end. H is a pipe, which forms a communication between the top and bottom of the cylinder; it leads down into a chest, *n*, upon which the cylinder is placed, and to which it is open at bottom; the chest is composed of plates screwed together, as shewn by the sections, *figs.* 3, 4, and 5, which also explain the construction of the sliding valve contained within the chest. In these figures, *s* is a short cylindrical pipe, fixed across within this chest, and communicating with the

pipe, H, at top, and the pipe I (which conveys the water away from the engine) at bottom. This short pipe has a water-tight division, *v*, (*fig.* 4.) in the middle of it, so that there is no direct passage through it from H to I; but there are four square holes made in the pipe, at equal distances round it, above and also below the division, as shewn at *figs.* 4 and 5. A cylinder or tube of brass, *t t*, is fitted upon the cylindric pipe, and slides up and down it, being packed with leather round the edges of the middle partition, as shewn in *fig.* 4, that no water may escape between the two cylinders. The sliding cylinder, *t*, is just half the length of the other, and when it is pushed down, as in the figures, it covers and stops the four holes in the pipe *s*, which are below the division *v*, and opens the four holes above the division, allowing a passage from the pipe H to the bottom of the cylinder C, *fig.* 1. On the contrary, when the slider is pushed up, the upper holes are closed, and the lower ones opened, making a passage from the cylinder bottom into I. The sliding valve *s*, besides the leather packing which surrounds the partition *v*, has leather placed at top and bottom of the fixed cylinder *s*, at *r*, *r*, and the ends of the slider are pressed upon these leathers, to make a tight joint when up or down, but the cylinder fits as tight as it can be made, independent of the leathers. The sliding valve has a pin projecting from each side of it, which pins are included between clefts made at the end of a forked lever *w x*, moveable on an axis *y*, which passes through the side of the chest in a collar of leather *z*, *fig.* 5, and has a long lever *o*, *figs.* 1 and 2, fastened upon it. By moving the upper end of this lever towards the engine, the sliding valve will be raised up; and by moving it in a contrary direction, the valve will be pushed down: *g* is a small iron rod, jointed to the upper end of the long lever by one of its ends, and the other is suspended by hooks from a spindle turning upon pivots, supported by the framing; this spindle has several levers upon it, similar to the working gear of a steam-engine, as follows: *h h e* is a three-armed lever; the arm, *e*, has a weight at the end, and is called the tumbling bob; *h* and *h* are two other arms, made in the same piece with *e*; these two latter arms strike against a pin, fixed across in the end of the rod *g*, which is forked, to admit the pin and the arms *h*, *h*, to act within the fork; *k* are two crooked levers, by which the spindle is moved as handles; these levers are struck by pins, *i*, fixed in a wooden rod *d d*, which is jointed to the working-beam K, and moves up and down with it: *e*, (*fig.* 2.) is a piece of wood fixed to the upright beams of the frame, having pins projecting from it, which catch the tumbling bob *e*, and prevent it moving too far; Q is a stop-cock in the main pipe, which regulates the quantity of water coming to the engine, and consequently the velocity with which the engine will work.

To describe the operation of the engine; suppose every thing to be in the position of the figures, and the pipes, cylinder, and pump, full of water, the sliding valve is down in the position of *fig.* 4, and therefore forms a communication from the top to the bottom of the cylinder: in this state the pressure of the descending column of fifty-four feet of water presses equally upon both sides of the piston of the cylinder, and therefore has no operation either way, the communication with the pipe I being stopped, so that the water cannot escape through it; but the pressure operates upon the lower surface of the forcer D of the pump, rising freely through the lower valve of the pump; this pressure, being unbalanced, raises up the working beam, and with it the piston of the cylinder and the rod *d*. This, as before mentioned, has pins, *i*, in it, one of which is seen, in *fig.* 1, to be just meeting the arm or handle *k*, which it raises, lifting the tumbling bob *e*, and turning the axis with all its levers. When the engine arrives at the top of the stroke, the tumbling bob passes the vertical point, and falls over on the other side of the centre; the arm *h* now strikes the cross pin in the end of the rod *g*, and by drawing it moves the lever *o*, and lifts up the sliding valve; this closes the communication between the top and bottom of the cylinder, and opens a passage to the pipe I, permitting the water to pass through the pipe into the well, and thus get away from the engine. This removes the pressure of fifty-four feet from beneath the piston, though it still remains acting at the top of the piston, and has added to it the twelve feet from the engine to the bottom of the well, in consequence of this column being suspended in the pipe I; this unbalanced pressure causes the piston to descend, bringing down the end of the beam K, and pump rod E with it: the valve in the bottom of the pump now shuts, and the water in the pump, being pressed by the forcer, opens the other valve at M, and goes up the pipe, *o*, to the reservoir, lifting a column of water of eighty feet. When the engine gets to the middle of its stroke, a pin in the other side of the wooden rod *d*, and therefore not seen, takes the lever, *k*, and forces it down, raising the tumbling bob, *e*, at the same time. By the time the piston arrives at the bottom of the cylinder, the tumbling bob is brought past the vertical position, and suddenly oversets, by its own weight, into the position of *fig.* 1. The lever, *h*, now runs against the pin, across the end of the rod *g*, and shoves it from the engine, moving the long lever, *o*, of the sliding valve, and the short lever, *w x*, (*fig.* 3.) down, just in the position of the drawings. This closes the four lower holes in the fixed cylinder, and prevents the water going down the pipe I, but at the same instant opens the four upper holes, forming a communication between the top and bottom of the cylinder. The pressure of sixty-six feet, which caused the piston to descend, is now removed, or rather balanced, by causing it to act equal beneath the piston; and the column of water of fifty-four feet, coming down the pipe A, and through the branch, forces open the lower valve of the pump, (the valve at M closing and supporting the column of eighty feet,) presses the under side of the pump forcer, and raises it up, as before described, moving the beam and piston with it; there now being an equal pressure, both above and below the piston, it will be moved up easily. When the piston arrives at the middle of its stroke, the preceding operations are repeated; thus the pin in the rod, *d*, takes the lever *k*, and raises it till it arrives at the top of its stroke, when it again passes the vertical position, and instantly falls over into the position first described; the lever *h*, taking the end of the rod *g*, and pushing it towards the engine, raises the sliding valve, opens the passage to the pipe I, and the whole column of sixty-six feet now presses upon the piston, and forces it down as before described, overcoming a column of eighty feet upon the pump. Though the diameter of the pump is larger than that of the cylinder, this happens from the chain of the piston acting upon a much longer lever than the pump. P and N are two air-vessels upon the pipes A and *o*, to equalize the action of the pump, and to prevent the shock which would otherwise take place when the sliding valve was suddenly shut, and the motion of the descending water thus checked.

A very complete pressure engine was erected by Mr. Trevathick at the Druid copper-mine, in Illogan, near Truro, in Cornwall; it acted with a double power, that is, the pressure was first applied to one side of the piston to force it up, and then on the other to force it down, in the same manner as a double acting steam-engine. It acted by two sliding valves instead of one, but they were so made that one

opened rather before the other ſhut, and this, though it waſted a ſmall quantity of water, by permitting it to eſcape, prevented the concuſſion of ſtopping the column of water, which indeed is always in motion.

PRESSURE.

Mr. Smeaton's Water preſsure Engine.

Fig 3 Plan

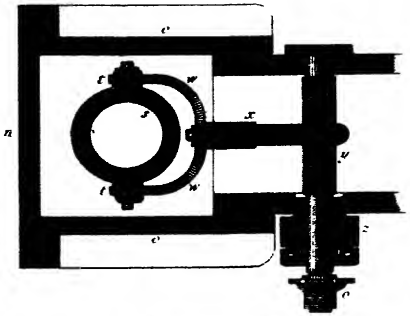


Fig 4. Section of the Valve

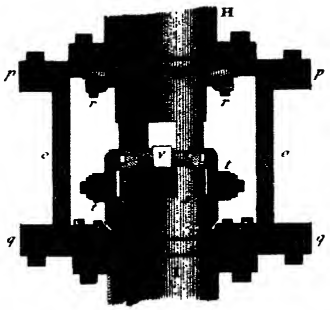
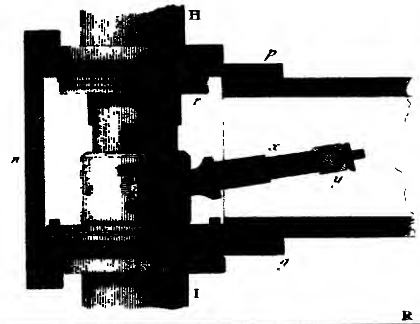


Fig. 5. Section



Front Elevation

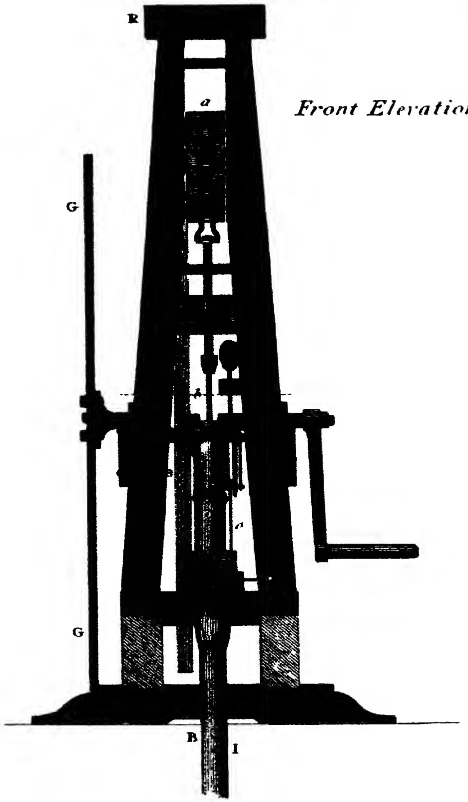
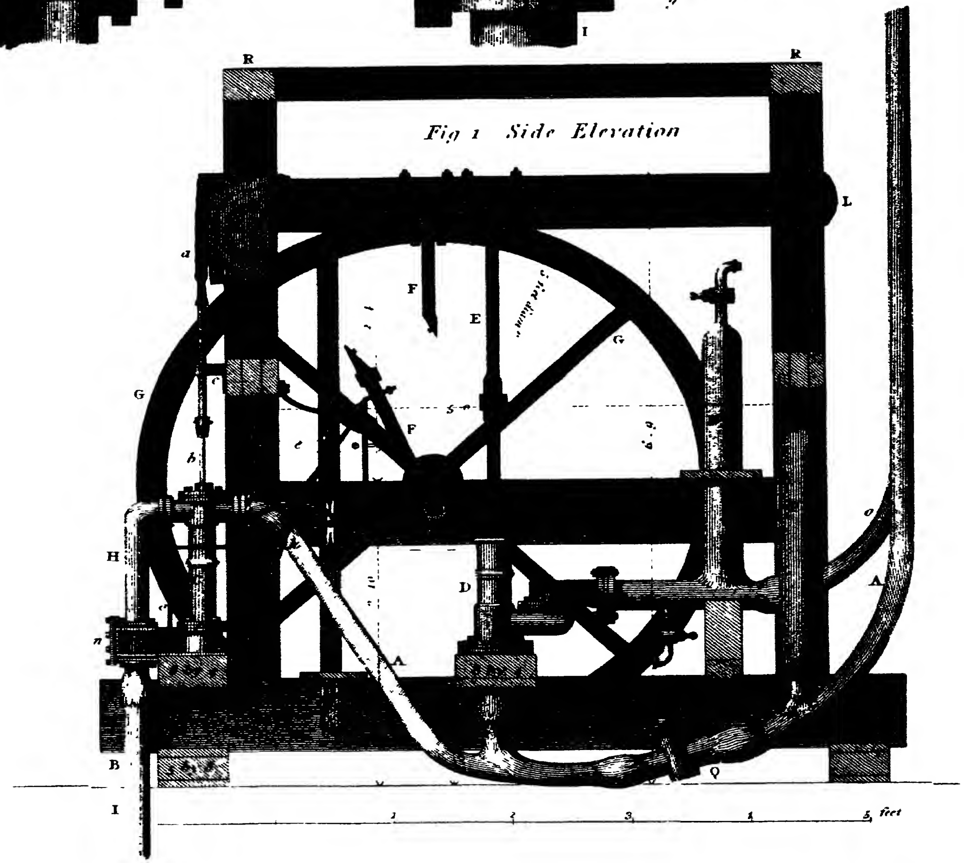


Fig 1 Side Elevation



Engraved by W. Lowry

Printing

PRINTING, Typographia, the art of taking impressions with ink, from characters and figures, moveable or immoveable, upon paper, vellum, or the like matter.

There are two kinds of printing; the one for books, the other from copper-plates, for pictures. The first called *common press printing*, the second *rolling press printing*.

The prime difference between the two consists in this, that the characters of the former are cast in relievo, and those of the latter are engraven in creux.

The art of printing is a modern invention: it is, indeed, of a very ancient standing among the Chinese; but then their printing is very different from our's. It must be owned, the European printing, in its original, was much the same with the Chinese; yet, as there was at that time no commerce or correspondence between Europe and China, the passage into the East by the Cape of Good Hope being as yet undiscovered by the Portuguese, there is no room to charge the Europeans with borrowing their art from the Chinese: but each must be owned to have fallen on the same thing, though at very different times. Father Couplet assures us, that printing has been in use in China from the year 930. Father le Compte speaks more largely; saying, that it has been there from almost all ages: he adds, that there is this difference between their's and our's, that whereas we have but a very small number of letters in our alphabets, and by the various arrangement of these, are able to form infinite volumes; we have the advantage, by making our characters moveable, to print the largest works with an inconsiderable quantity of letter; those that served for the first sheets, serving over again for the succeeding ones: the Chinese, on the contrary, by reason of the prodigious number of their letters, are precluded this resource; and find it more easy and less expensive to cut all their letters on wooden blocks; and thus to make as many blocks as there are pages in a book; and these of no farther use but for that single work. Their method of printing see hereafter.

Printing, *Origin of*.—Who the first inventors of the *European* printing were, in what city, and what year, it was at first set on foot, is a famous problem long disputed among the learned. In effect, as the Grecian cities contended for the birth of Homer, so do the German cities for that of printing.

Mentz, Haerlem, and Strasburgh, are the warmest on this point of honour: Italy also would have entered the

lists; but the suffrages being at first divided between the first three pretenders, they are left in possession of the question, which, in reality, is not yet justly decided; though it must be owned, Mentz has always had the majority of voices.

We shall not here enter into a nice disquisition of the merits of the cause, but only propose the pretensions of each. John Mentel of Strasburgh, John Guttenberg and John Faust of Mentz, and L. John Coster of Haerlem, are the persons to whom this honour is severally ascribed by their respective countrymen; and they have all their advocates among the learned. Mentel, a physician of Paris, enters the lists in behalf of his namesake of Strasburgh; and contends that it was he who first invented printing in the year 1440, and that, in consideration of it, the emperor Frederic III. gave him a coat of arms corresponding to it, in the year 1466. He adds, that Guttenberg, whom he had taken in as a partner, or associate, carried it to Mentz, where he took in Faust a partner. John Gensfleisch, a native of Mentz, who was his servant, communicated the art to J. Guttenberg, whom Mentel had employed in making some of his tools; and becoming thus possessed of the art, they removed and settled at Mentz, where it was perfected by the assistance of John Faust. But this account depends on a Strasburgh chronicle of very doubtful authority, and is contradicted by the chronicle of Cologne, Trithemius, and Wimpeling. The last-mentioned writer expresly says, that the art of printing was invented, incompletely, at Strasburgh, by Guttenberg, and perfected at Mentz. Here Mentel acquired it from Guttenberg and Faust, and returning to Strasburgh about the year 1455, practised it in connection with Eggelstein.

The Haerlemers, with Boxhornius, Scriverius, &c. refer the first invention to Laurens Janzs Coster, or Laurence John Coster, (called Coster on account of the public office distinguished by this appellation, which he sustained at Haerlem, and which was hereditary in his family,) of Haerlem, in the year 1430, adding, that his associate Guttenberg stole away his tools while he was at church, and carried them to Mentz, where he set up for the first inventor; though others attribute this theft, &c. to his partner Faust. And others, again, with greater probability, ascribe it to John Gensfleisch senior, one of his servants, in the year 1441: and with these types, &c. of Laurence, two small works were printed at Mentz in 1442. The principal evidence in favour of Haerlem, is Cornelius, who had been a servant of Laurence, and afterwards a book-binder in that city, on whose authority Adrian Junius, M. D. founds his account, which appears to have been drawn up between the years 1562 and 1575, and published at Leyden in 1588. The learned Meerman, in his "Origines Typographicæ," 1765, has amply vindicated and confirmed the account which Junius gives of the fact; though he disputes and sufficiently invalidates what this writer says, as to the types which were used by Coster, at Haerlem. These, he shews, were neither cut nor fusible metal types, but separate wooden types.

Munster, Polydore Virgil, Pasquier, &c. will have Guttenburg, or Guttemburg, to have really been the inventor of printing: and add, that he took in Faust and Schoeffer for associates.

Naude, in his "Mascurat," espouses the cause of Fust, or Faust, or Faustus; and will have him to be the first printer in Europe, and that he took in Guttenberg for a partner. His reason for putting Faust in possession of this privilege is, that the first books that were printed appear to have been all of his impression. To this purpose it is alleged, that it is more than probable, if Guttenberg or Coster had had a greater or an equal share in the invention, they would not have allowed him to attribute the whole to himself and his son-in-law Schoeffer, as he has done, without ever offering to do the like, or in the least contradicting him, and asserting their own right.

The true state of the case seems to be this, that metal types were first invented at Mentz; of these there were two sorts, *viz.* those that were cut, and those that were cast in matrices. The invention of the former has been ascribed by some writers to Faust, but without sufficient authority; the real inventor being John Gensfleisch senior, who had brought the art of printing with wooden types from Haerlem to Mentz, with whom John Gensfleisch junior, called Guttenberg, might probably have concurred. The era of this invention must be about the year 1442 or 1443; for John Gensfleisch senior came to Mentz in 1441, and the Latin bible, with metal types, was printed in 1450, which could not require less than seven or eight years.

The latter were invented by Peter Schoeffer, the servant and son-in-law of Faust, who settled at Mentz in the year 1449 or 1450, and having acquired under the two Gensfleischs the art of cutting types, remedied the inconvenience of this method by contriving to cast them, which must have been practised before the year 1459. The partnership that subsisted between Gensfleisch and Faust, and the relation between Schoeffer and Faust, have probably given occasion for ascribing to him the merit of the invention of printing with metal types, in which, from the connections of this kind, he probably might have had some concern.

The editions above referred to in Naude's account are, 1. The "Codex Psalmorum," printed in 1457, which is the most ancient book known to be printed with a date or inscription, and is lodged in the emperor's library at Vienna. 2. The "Rationale Divinorum Officiorum" of William Durand, printed at Mentz in 1459, in folio. This "Rationale" is in the earl of Pembroke's library. Malinkrot has erroneously supposed this to be the first printed book. 3. The "Catholicon Januensis," dated in 1460, and now in the king's library. Faust's name, indeed, is not to this; but it is perfectly like the following ones where it is. It is said that the first printers did not subjoin their names and inscriptions at the end of their books till the year 1457: and this they continued to do till Faust either died or left off business. 4. The Latin Bible of 1462, being the second edition of it, now in the French king's library. 5. "Tully's Offices," in quarto (the rest being all folios), in the year 1465, and 1466, for there are copies in the Bodleian, and the library of Corpus Christi college, Oxon, of both these dates. Some eminent writers have asserted that this is the first printed book. 6. Other bibles of 1471. 7. "St. Augustine Civitate Dei," 1473. 8. "Mercurius Trismegistus de Potestate & Sapientia Dei," in 1503. 9. "Titus Livius," in 1518, &c.

Add to this, that at the end of Livy is a privilege granted by the emperor Maximilian to Schoeffer, grandson of Faust, for the sole power of printing that author for ten years; and for six years, to all the other books he should print thereafter; in consideration of Faust's having invented the art of printing. This privilege is dated 1518, and signed Jac. Spiegel.

Erasmus, however, in the epistle after that privilege, does not positively aver the fact; he only observes, that the first, or the chief inventor of that art, is held to be J.

Fauſt. In the advertiſement to the ſaid book, Nic. Carbachius ſpeaks to the ſame effect as to the privilege, and Eraſmus.

As to Guttenberg, Mentel, and Caſtor, Naude obſerves, the perſon is not yet born that can ſay he has ever ſeen books printed by any of them, before or as early as thoſe of Fauſt. All that is urged on their behalf, is only founded on reports, conjectures, probabilities, forged authorities, and the jealouſies of cities againſt one another.

Yet Salmuth, in his additions to Pancirollus, cites a public act, by which it appears that Fauſt, after having invented printing, and ſuſtained it a long time on his own footing; at length took in Guttenburg as partner, to contribute to the expence; which was very great, by reaſon the firſt books were moſt of them printed on vellum, or at leaſt on parchment, and after the Chineſe way.

But the cauſe is not thus decided: the advocates for Coſter urge divers things, which ſeem to put him in the place here aſſigned to Fauſt. Mr. Ellis, in the Philoſophical Tranſactions, fathers books on him prior to any of thoſe above referred to Fauſt, and even ſome as early as 1430 and 1432. It is certain, the Haerlemers ſhew printed books of that date, which agreeing ſo well with the account given by Theod. Scriverius, and others, leaves Mr. Ellis little room to doubt, whether the honour of the invention be his or the other's due. All that belongs to Fauſt, according to this writer, is the honour of eſtabliſhing the art in greater luſtre and perfection at another place many years after.

But the difficulty lies, either in ſhewing why the practice ſhould be at a ſtand from 1432, to the reviving of it at Mentz by Fauſt and Schoeffer in 1465, or elſe in giving ſome account of the condition and progreſs of this invention during that interval.

Now, Boxhornius, Scriverius, and other authors, expreſsly affirm, that ſo large a work as the "De Spiegel, Speculum Salutis" of Coſter, ſhewn at Haerlem for the firſt printed book, could never be his firſt eſſay: he muſt have had the art in its rougher rudiments before, and have made many trials on leſs works: no doubt his firſt attempts were on looſe ſheets, which we may ſuppoſe were eaſily loſt. In effect, it muſt be allowed no inconſiderable argument in Coſter's behalf, that the rudeſt and moſt artleſs performances ſeem to be his. Mr. Ellis mentions ſome things of this kind without date, which he had ſeen in the king's library at St. James's, in that of Bennet college and the Bodleian at Oxford, with all the marks of the utmoſt ſimplicity, and which might fairly bid for firſt eſſays. There is ſomething ſo aukward and coarſe in them, that any body almoſt might have done them; mere nature being ſufficient, without any art or experience at all. The ink was only common writing ink, unartfully ſpread upon wooden blocks, very clumſily cut, &c.

By this time we have traced up the art to ſuch a ſtate, that it may, perhaps, ſcarcely ſeem worth the conteſting who it was invented it; and no doubt printing, as it now ſtands, owes more to the genius and addreſs of ſome of the later improvers than it did to its firſt author.

The ſame conſideration may make us more eaſy under our preſent ignorance of the inventors of moſt other arts; many of which had ſuch ſimple unmeaning originals, that it might perhaps be no mighty credit to be eſteemed the authors of inventions not leſs artful and ingenious.

We ſhall conclude this account of the origin of printing with an abridgment of the hiſtory of it, given by the late Mr. Bowyer. This writer obſerves, that the honour of having given riſe to this art has been claimed by the cities of Haerlem, Mentz, and Straſburgh. To each of theſe cities it may be aſcribed in a qualified ſenſe, as they made improvements upon one another. But the real inventor of printing was Laurentius, of Haerlem; who proceeded, however, no farther than to ſeparate wooden types. His firſt eſſay was about the year 1430; and he died about 1440, after having printed the "Horarium," the "Speculum Belgicum," and two different editions of Donatus. Some of Laurentius's types were ſtolen from him by one of his ſervants, John Gensfleiſch, ſenior, who became the firſt printer in Mentz, and publiſhed, in 1442, "Alexandri Gali Doctrinale," and "Petri-Hiſpani Tractatus." Theſe works were executed with wooden types, cut after the model of thoſe which he had ſtolen. In 1443, Gensfleiſch ſenior entered into partnerſhip with Fauſt (who ſupplied money), Meidenbachius, and others; and in 1444 they were joined by John Gensfleiſch junior, who was diſtinguiſhed by the name of Guttenberg. Guttenberg, by the aſſiſtance of his brother, Gensfleiſch the elder, firſt invented cut metal types, with which was printed the earlieſt edition of the bible. This edition appeared in 1450, and the completing of it took up ſeven or eight years. Guttenberg uſed none but either wooden or cut metal types. The carrying of the art to perfection was owing to Peter Schoeffer, the ſervant and ſon-in-law of Fauſt, who invented the mode of caſting the types in matrices; and who was probably the firſt engraver on copper-plates. The firſt book printed with the improved types was "Durandi Rationale," in 1459. More copies of the earlieſt books were printed on vellum than paper. This method, however, was ſoon changed; and paper was introduced for the greateſt part of the impreſſions, a few only being printed on vellum, for curioſities, and for the purpoſe of being illuminated.

With regard to the claim of Straſburgh, it appears that Guttenberg had endeavoured to introduce printing into that city before he joined his brother at Mentz; but without ſucceſs. The firſt actual printers at Straſburgh were Mentelius and Egleſtenius; and there is no certain proof of a ſingle book having been printed there till after 1462. The diſperſion of the Mentz printers, in that year, occaſioned the art to ſpread rapidly through Europe; and in 1490 it reached even to Conſtantinople. Thoſe who wiſh to ſee this ſubject farther diſcuſſed, and to find the authorities on which this abſtract of the riſe of printing is founded, may conſult Meerman's "Origines Typographicæ," quarto, 1765, and Bowyer's "Origin of Printing," edit. 2.

Printing, *Progreſs of.* The firſt printers, then, whoever they were, made their firſt eſſays on wooden blocks, or forms, after the Chineſe manner.

It is not improbable, ſays Mr. Bagford, they might take the hint from ancient medals and ſeals. To this purpoſe, it is obſerved, that the arts and ſciences, eſpecially ſtatuary and ſculpture, were arrived at ſo great perfection among the Romans, at the time when that empire was in its greateſt glory, that it is much to be wondered at that the art of printing was not found out among them; an art ſo nearly allied to that of the cutting of ſeals and the dies of medals.

The making of theſe dies, and the ſtamping of their coins with them, was, in reality, no other than printing on metal; and their impreſſing their ſeals, cut in cornelians, agates, &c. on wax, was another ſpecies of printing on this ſubſtance. And finally, a third ſort of printing among them, was the impreſſing the name of the workmen on their pieces of fine earthen-ware.

Montfaucon, in his Antiquities, gives the figures and de-

ſcriptions of ſeveral very large ſigilla of the Romans, in which the names were all cut in hollow, in capital letters; and he imagines, that the uſe of theſe was to mark large earthen veſſels with, while the clay was ſoft, and particularly thoſe large veſſels in which the Romans kept their wines. It does not ſeem that this diligent enquirer into antiquity ever met with any of theſe ſigilla with the letters or characters in relief, or ſtanding out in the manner of our modern types for printing, ſince he mentions none ſuch; yet the remains of the Roman antiquities in terra cotta, or earthen-ware, ſhew that they had ſome ſuch, though they were leſs common than the others; theſe veſſels ſometimes being marked with letters going in, though in general they have them all ſtanding out, as muſt be the caſe when the impreſſion was given from a ſigillum cut in creux.

There is now, in the collection of the duke of Richmond, a ſigillum of the other more rare kind, which brings the diſcovery very near to that of printing: on this all the letters are raiſed, as is alſo the verge or rim of the ſeal in the manner of our types uſed this day in printing. The ſtamp is made of true ancient braſs, and has on it the common green coat of ærugo, which diſtinguiſhes the true antique medals. The plate is nearly two inches long, and nearly an inch in breadth, and has on the back part a ring for the convenience of holding it for making the impreſſion. The letters ſtand in two rows; they are the common Roman capitals, very well made, and their faces all ſtand exactly on the level with one another, and with the ſurface of the verge of the ſeal. This ſeal was exactly of the nature of our method of printing ſo many letters at once. It contains the name of one Caius Julius Cæcilius Hermias, ſome private man, as we have no account of any perſon of this name upon record. It ſerved him probably to ſet his name to any thing, to ſave him the trouble of writing; and the name being that of ſome private man ſeems alſo to prove, that theſe ſigilla were very common among that people. It was evidently made to be uſed on parchment, or ſome other ſuch thin ſubſtance; and the manner of uſing it muſt have been by firſt dipping into ink, or ſome other coloured matter, not plunging it ſo far as to touch the ground, ſo that the letters only became marked, and gave their figures on the paper. The ground of this ſeal is very rough and uneven, and thence alſo it is plain, that the uſe of it was not to preſs down any ſoft ſubſtance, ſuch as clay, or the like; becauſe the imperfection of the ground would, in that caſe, have been ſeen; whereas in the uſe it was really intended for, the ground never gave any impreſſion, and therefore there was no reaſon for beſtowing any pains on the working it even.

The firſt uſe of printing among the later ages, was by wooden blocks in this very manner; and it was not till long after this invention, that we learned the way of uſing ſeparate types for the letters; and theſe were then called *typi mobiles*, in oppoſition to the blocks, where the whole page was contained together, which was called *typi fixi*. This ſignet of the duke of Richmond's, which was found near Rome, is truly and properly one of thoſe *typi fixi*, and prints off its impreſſion on paper with our modern printer's ink, as well as any ſet of letters cut in this manner can be expected to perform. This ſeems, therefore, the moſt ancient ſample of printing that we know of; for, by the appearance of the metal, it ſeems to be of the Higher Empire.

It is plain, by this ſtamp, that the very eſſence of printing was known to the Romans; for they had nothing to do, but to have made a ſtamp, with lines three or four times as long, and containing twenty lines inſtead of two, to have formed a frame of types that would have printed a whole page as Coſter's wooden blocks, uſed in printing the book called "Speculum Salutis," which, as ſome ſay, is the firſt book printed in the year 1440, and conſiſting of pictures of ſtories out of the bible, with ſome of the verſes underneath each page; being printed from a block of wood, like a wooden cut. This was the firſt eſſay of fixed types, from which the moveable, or common ſeparate types were ſoon deduced; and it ſeems ſtrange that the Romans, who were as ſagacious a people as any in the world, ſhould not as eaſily have fallen upon the uſe of ſeparate types, in which the whole art of modern printing conſiſts, from ſuch ſignets as theſe, as the later ages from Coſter's wooden blocks, which were plainly no other than larger works of the ſame kind.

Cicero, in his book "De Natura Deorum," has a paſſage from which Toland ſuppoſes that the moderns took the hint of printing. That author orders the types to be made of metal, and calls them *formæ literarum*, the very words uſed by the firſt printers to expreſs them. It is plain from Virgil, that brands, with letters of the owner's name, were in uſe in his time for the marking of cattle. And we have an account of the ſame artifice that is now uſed for the painting of cards being uſed by the emperor Juſtin, who could not write. There was a ſmooth board, with holes cut through it, in form of the letters of his name; and when he had occaſion to ſign any thing, this was laid on the paper, and he marked the letters with a pen or ſtylus dipped in red ink and directed through the holes. Philoſ. Tranſ. N° 479, p. 393.

But others rather imagine the art of printing to have come from the method of making playing cards, which, it is certain, bear a nearer reſemblance to the primitive proceſs of printing than ſeals; as appears from the firſt ſpecimens of that art above mentioned.

The book at Haerlem, the vocabulary called "Catholicon," and the pieces in the Bodleian and Bennet college, are all performed in this way; and the impreſſion appears to have been given on one ſide of the leaves; after which the two blank ſides were paſted together.

But they ſoon found the inconveniencies of this method, and therefore bethought themſelves of an improvement; which was by making ſingle moveable letters, diſtinct from one another.

Theſe being firſt done in wood, gave room for a ſecond improvement; which was the making of them, at length, of metal; and in order to that, cutting moulds, matrices, &c. for caſting them.

From this ingenious contrivance we ought to date the origin of the preſent art of printing, as practiſed throughout Europe; contradiſtinguiſhed from the methods of the Chineſe abroad, and the card-makers at home, which were the ſame art, only practiſed in a different place, or with a different view.

And of this, Schoeffer, or Scheffer, firſt ſervant, and afterwards partner, and ſon-in-law of Fauſt, at Mentz, above mentioned, is pretty generally allowed the inventor; ſo that he was properly the firſt printer with fuſile types.

But the art being yet in its infancy, there were ſome imperfections in the books they printed; among the reſt was the want of capital letters: hence they left the places of the initial letters blank, and gave them to the illuminers to paint in gold, or azure, though others ſay, this was done deſignedly, to enable them to paſs off their books for manuſcripts.

Some authors tell us, that Fauſt carrying a parcel of his bibles to Paris, and offering them to ſale as MSS., the French, upon conſidering the number of books, and their exact conformity with one another, even to a point, and that

the beſt book-writers could not be near ſo exact, concluded there was witchcraft in the caſe; and, by either actually indicting him as a conjuror, or threatening to do ſo, extorted the ſecret. And thence the origin of the popular ſtory of Dr. Fauſtus.

From Mentz, about the year 1462, when it was taken, plundered, and deprived of all its former rights and franchiſes, the art of printing ſoon ſpread itſelf throughout a good part of Europe; Haerlem and Straſburgh had it very early; which, as authors repreſent it, occaſioned their pretending to the honour of the invention.

From Haerlem it paſſed to Rome in 1466, where the Roman type was introduced in 1467, which was ſoon after brought to great perfection; and into England in the reign of Henry VI. by means of Thomas Bourchier, archbiſhop of Canterbury, who ſent R. Tournour, maſter of the robes, and W. Caxton, merchant, to Haerlem, to learn the art. Theſe privately prevailing with Corſellis, an under-workman, to come over, a preſs was ſet up at Oxford.

This account depends on the authority of an old manuſcript chronicle, ſaid to be preſerved in the archbiſhop's palace, and cited by Atkins, in his "Original and Growth of Printing in England," publiſhed at London in 1664. This chronicle informs us, that the execution of the buſineſs intruſted with Tournour and Caxton, coſt fifteen hundred marks; and that printing was ſet up at Oxford before there was any printing preſs or printer in France, Spain, Italy, or Germany, except the city of Mentz, which claims ſeniority as to printing even of Haerlem itſelf, calling herſelf *Urbem Moguntinam artis typographicæ inventricem primam;* though it is known to be otherwiſe, that city (as the chronicle adds) gaining that art by the brother of one of the workmen at Haerlem, who had learned it at home of his brother, and afterwards ſet up for himſelf at Mentz. This preſs at Oxford was at leaſt ten years before there was any printing in Europe (except at Haerlem and Mentz), where alſo it was but new-born. This preſs at Oxford was afterwards found inconvenient to be the ſole printing place in England, as being too far from London and the ſea; upon which the king ſet up a preſs at St. Alban's, and another at the abbey of Weſtminſter. But the authority of this chronicle has been warmly diſputed by Mr. Palmer in his "Hiſtory of Printing," 1733, book iii.; Dr. Ducarel, in his letter to Meerman, Dr. Middleton, Ames, and others, who maintain that there was no printing in this kingdom till the introduction of it by Caxton, who had acquired it in his travels abroad, about the year 1474, or as ſome ſay, 1470 or 1471.

But Mr. Bowyer, in his notes to the Abridgment of Dr. Middleton's "Diſſertation on the Origin of Printing in England," hath offered ſeveral reaſons to ſhew, that the account given in Atkins's record is not ſo incredible or improbable as ſome perſons have imagined.

Mr. Meerman, in his learned work already cited, is a ſtrenuous advocate for the authenticity of this record: and he apprehends that the period to which this hiſtory relates, muſt have been between the years 1454 and 1459; becauſe Bourchier was made archbiſhop of Canterbury in 1454, and Edward IV. ſucceeded Henry VI. in 1460. This accurate writer has produced a variety of evidence in ſupport of the claims of Corſellis, for which we muſt refer to his elaborate work, and particularly to his letter in reply to Ducarel, tom. ii. p. 19, &c., and to Mr. Bowyer, ubi ſupra; which evidence derives much confirmation from a book with a date of its impreſſion from Oxford, anno 1468, copies of which are in ſeveral public libraries, particularly at Cambridge, Oxford, lord Pembroke's library, &c. This is a ſmall volume of forty-one leaves in quarto, with this title; "Expoſitio Sancti Jeronimi in Symbolum Apoſtolorum ad Papam Laurentium," and at the end are the following words, "Explicit Expoſitio, &c. impreſſa Oxoniæ & finita, Anno Domini MCCCCLXVIII. XVII die Decembris."

If the authority of this book be admitted, it is a clear proof and monument of the exerciſe of printing in Oxford ſeveral years before Caxton began to deal in it. Dr. Middleton, indeed, endeavours to ſhew that the date is a falſe one; and, not to mention the reſt of his arguments, confirms his opinion from this circumſtance, that we have no other fruit or production from the preſs at Oxford for eleven years next following. But this objection is invalidated by two conſiderations; firſt, that Corſellis's books may have been loſt, a thing by no means uncommon in thoſe days of ignorance; and, ſecondly, that the civil wars broke out in 1469, which might probably oblige our Oxford printer to ſhut up his preſs.

Mr. Bowyer produces a paſſage from the ſecond part of Shakſpeare's Henry VI., as a farther evidence of a more early introduction of printing into England than hath generally been ſuppoſed. See alſo Meerman ubi ſupra, monitum noviſſimum, prefixed to tom. ii.

The reſult of the whole is, that this fact doth not at all derogate from the honour of Caxton, who was the firſt perſon in England that practiſed the art of printing with fuſile types, and conſequently the firſt who brought it to perfection: whereas Corſellis printed with ſeparate cut types in wood, being the only method which he had learnt at Haerlem.

In 1467, printing was ſet up in the city of Tours; at Reutlingen and Venice in 1469; and probably in the ſame or next year at Paris, where Gering, Crantz, and Friburger, all Germans, invited thither by two doctors of the Sorbonne, ſet up a preſs in that learned houſe.

Hitherto there had been nothing printed but in Latin, and the vulgar tongues; and this firſt in Roman characters, then in the Gothic, and at laſt in Italic. But in 1480, or, as ſome ſay, in 1476, the Italians caſt a ſet of Greek types; and it was at Venice, or, as ſome ſay, at Milan or Florence, that the firſt editions in that language appeared.

Here we may obſerve, that the firſt Greek printing was a few ſentences of Tully's Offices at Mentz, in 1465, which were very incorrect. In the ſame year, ſome Greek quotations in an edition of Lactantius's Inſtitutes, were neatly printed, in a monaſtery, in the kingdom of Naples. The firſt whole Greek book was the Grammar of Conſtantine Laſcaris, at Milan, in 1476. See Bowyer, ubi ſupra, Appendix, N° 1; or the excellent edition of the Biographia Britannica, by Dr. Kippis, art. *Atkins*, note (A).

The Italians, too, have the honour of the firſt Hebrew editions, which were printed about the ſame time with the Greek, at Soncino, a little city in the duchy of Milan; under the direction of two Jewiſh rabbins, Joſhua and Moſes, whoſe works are dated in the year of the world 5244, anſwering to the year 1484 of the Chriſtian era.

Towards the end of the ſixteenth century, there appeared various editions of books in Syriac, Arabic, Perſian, Armenian, Coptic, or Egyptian characters; ſome to gratify the curioſity of the learned, and others for the liturgic uſes of the Chriſtians in the Levant: theſe were printed chiefly at Paris; whither puncheons and matrices were ſent from Conſtantinople by M. Savary, then ambaſſador at the Porte.

Out of Europe, the art of printing has been carried into the three other quarters of the world: for Aſia, we ſee impreſſions of books at Goa, and in the Philippines; at

Lima, Boſton, Philadelphia, Mexico, &c. for America; and at Morocco for Africa.

The Turks, indeed, are ſaid rigorouſly to prohibit printing throughout their empire, as imagining that the too free communication with books might occaſion ſome change in religion or government, but this is to be underſtood with ſome limitation: and it is certain that the Jews have ſeveral editions of their books printed at Conſtantinople, Theſſalonica, &c.

Printing, *Method of.* For the printing letters ſee the annexed ſpecimen.

For the method of forming and caſting them, ſee *Letter* Foundery.

And for the art of engraving the puncheons, matrices, &c. in order thereto, under the articles Engraving, Puncheon, Matrice, &c.

The workmen employed in the art of printing are of two kinds; *compoſitors*, who range and diſpoſe the letters into words, lines, paſſages, &c. according to the copy delivered them by the author; and *preſſmen*, who apply ink upon the ſame, and take off the impreſſion. See Composition, &c.

Office of the Compoſitor.—The types, being caſt, &c. are diſtributed, each kind by itſelf, among the diviſions of two long wooden frames, an upper and under one, called *caſes;* each of which is divided into little cells, or boxes, of different ſizes.

The boxes of the upper caſes are in number ninety-eight; and in theſe are diſpoſed the capitals, ſmall capitals, accented letters, &c. In the cells of the lower caſe, which are fifty-four, are diſpoſed the common running letters, with the points, commas, ſpaces, quadrats, &c.

Each caſe is placed a little aſlope, like a reading-deſk, that the operator may reach the upper boxes the better, and be in leſs danger of mixing the letters by ſtretching his arm over them.

The compoſitor's poſt is againſt the middle of the caſe, and he works ſtanding, holding an inſtrument, uſually made of iron, called the *compoſing-ſtick*, in one hand; with the other he takes the types as he requires them, out of the boxes; ranges them on a ſlip of braſs, called a *rule*, in his compoſing-ſtick; and, putting a ſpace, to make a blank between each two words, forms one line after another, till the ſtick being full, he empties it out upon another inſtrument, called the *galley;* ſeveral of which ranged and wedged tight in an iron frame, called a *chaſe*, are ready for the preſs.

This ſhort view of compoſing may need to be farther illuſtrated and enlarged upon. The compoſing-ſtick, then, (repreſented *Plate* IV. *Printing*, *fig.* 5.) conſiſts of a plate, or ſlip of iron, braſs, wood, &c. more or leſs broad, and contrived ſo as to be made more or leſs long, according to the width of the page, and the number of lines to be compoſed in it.

From the right ſide of this plate ariſes a ledge *a a*, about half an inch high, running the whole length of the plate, and ſerving to ſuſtain the letters, the ſides of which are to reſt againſt it; from the ſame plate likewiſe ariſe three other leſſer pieces, *b* and *c*, *c*, two of which, *c*, *c*, are contrived to ſlide along it, ſo that the two pieces may be either approached or withdrawn at pleaſure, to adjuſt the length of the line to the meaſure intended. Add, that where marginal notes, references, &c. are required in a work, the two ſliding-pieces, *c*, *c*, are opened in the compoſing-ſtick to a proper diſtance from each other.

Before the workman proceeds to compoſe, a rule, or thin ſlip of braſs plate, cut to the length of the line, and of the ſame height as the letter, is placed in the compoſing-ſtick againſt the ledge of it, for the letter to bear immediately againſt.

Things thus prepared, the compoſitor having the copy lying before him, and the ſtick in his left hand, with the right he picks up the letters, ſpaces, &c. and places them againſt the rule; while with the thumb of the left he preſſes them cloſe to the upper ſcrew, or cheek: and thus keeps them tight and ſteady; while the other hand is conſtantly employed in ſetting in more letters; the whole being performed with a degree of expedition and addreſs not eaſy to be imagined.

A line being thus compoſed, if it end with a word or ſyllable, and fill the meaſure, there needs no farther care; otherwiſe more ſpaces are to be put between the ſeveral words to juſtify the lines, *i. e.* to make the meaſure quite full, ſo that every line may end even; and thus he proceeds to another line.

The ſpaces here uſed are a ſort of blanks, of the like dimenſions as the letters, but leſs high; and whoſe faces, therefore, when ſet, do not appear, nor give any impreſſion. They are of ſeveral kinds, according to the dimenſions of the whites or intervals to be made by them, *viz.* quadrats, to fill up a break at the end of a paragraph, or the like; m quadrats, which are ſquare, and of the thickneſs of an m, ſerving to make the diſtance after a period, or between ſentence and ſentence; n quadrats, of the thickneſs of an n, to be placed after colons, ſemicolons, and commas; and thick or thin ſpaces, to be uſed between the words in juſtifying, as above.

For marginal notes, in the ſpaces reſerved for them between the two ſliding pieces of the compoſing-ſtick, are put little quadrated pieces of metal, called *quotations;* which are juſtified by other ſmaller pieces; a ſlip of ſcaleboard being placed from the top of the page to the bottom, to keep the note and text at due diſtance.

The firſt line being thus completely juſtified, the compoſitor advances to the next; in order to which, he moves the braſs rule from behind the former, and places it before it, and thus compoſes another line againſt it, after the ſame manner as the former: and thus he goes on till his ſtick be full, which he empties into the galley, after the manner following:

Taking the rule from behind the laſt line, he places it before it; and with his two middle fingers ſqueezes the lines in the ſtick cloſe; his two fore-fingers at the ſame time being applied on the outſide of the rule: thus he lifts them out of the ſtick, and clapping his two thumbs behind the firſt line, lifts them into the galley; taking care to diſengage his two thumbs without breaking the lines.

The compoſitor having thus ſet the proper number of lines in the ſtick, *viz.* four, five, ſix, or more, and emptied them out into the galley, he again fills and empties, as before, till a complete page be formed; remembering at the bottom of every page to ſet a line of quadrats, and at the end of it the firſt word of the page enſuing, for a catch-word; and if it be the firſt page of the ſheet, one of the letters for a ſignature.

The galley is a flat wooden tray or diſh, in form of a long ſquare; of a length and breadth proportionable to that of the page; it conſiſts of two parts, the upper, called the *ſlice*, by which the pages of large volumes, when compoſed, are ſlidden upon the ſtone; the other, called the *coffin*, which is the body of the galley, is ledged on three ſides to contain the ſlice; the inner ledge not to exceed half an inch in height, that the compoſed page riſing above it by one half the height of the letter, may be tied up, or bound down, and removed without danger. When at work,

the compositor places this galley at the top of the case, and it is prevented by a wooden pin from sliding down the boxes.

The page, then, being composed, and ranged in the galley, he ties it up in it with a cord or packthread, and sets it by, and proceeds to the next, till the number of pages of the sheet be completed; which done, he carries them to the imposing or correcting stone, there to range them in order in a chase; which they call *imposing*.

The chase is a rectangular iron frame of different dimensions, according to the size of the paper to be printed on, having two cross pieces of the same metal, called a *long* and *short cross*, mortised at each end into the frame, so as to be taken out occasionally.

By the different situations of these crosses, the chase is fitted for different volumes, for quartos and octavos; one traverses the middle lengthwise, the other broadwise, so as to intersect in the centre, which is the most customary situation; for twelves and twenty-fours, the short cross is shifted nearer to one end of the chase. For folios, the long cross is left entirely out, and the short one placed in the middle; and for broad-sides, or sheets printed on one side only, both crosses are set aside.

To dress the chase, or range and fix the pages in it, they make use of a set of furniture, consisting of reglets, or slips of wood of different dimensions, and about half an inch high, that they may be lower than the letters; some of these are placed at the top of the pages, called *head-sticks;* others between them to form the inner margin, called *gutter-sticks;* others at the sides, called *side-sticks;* and others at the bottom, called *foot-sticks*.

The pages then being placed in order on the stone, the chase is put over them, and the reglets applied between the letter and the chase, in the position above-mentioned; the whole is locked up by means of small pieces of wood, cut in the wedge-form, called *quoins*, which are driven with a mallet and shooting-stick to a sufficient tightness. Before the form be quite locked up, they press down the same, by passing a smooth piece of wood, called the *plainer*, over the letters, to make their surfaces stand flat and even; and, when locked up, they shake it, to see that nothing stir.

In this condition, the work is called a *form*, containing more or fewer pages, according to the volume.

As there are two forms required to every sheet, when both sides are to be printed, it is necessary they be exactly of the same length and breadth; *i. e.* the corresponding reglets, head-sticks, &c. are to be equal in both forms, that the pages may fall exactly on the back one of another; which is called *register*.

Here, then, properly ends the compositor's office; the form, thus finished, being to be committed to the pressman.

Indeed, as it is impossible but there must be mistakes in the work, either through the oversight of the compositor, or by the casual transposition of the letters in the cases; after drawing off a proof, it is delivered to the corrector; who reading it over, and rectifying it by the copy, it is remanded to the former operator, to be corrected accordingly. For the characters used in correcting a sheet for the compositor, see Correction.

The compositor, then, unlocking the form upon the correcting-stone, by knocking out or loosening the quoins, and spreading his corrected proof so as that the lines of it range with the respective ones of the metal, by running his eye along both, he easily spies where corrections are to be made; according to which, he proceeds to pick out the faulty letters, points, &c. with a sharp-pointed steel bodkin, and puts others in their places.

Where the alterations are considerable, and particularly where insertions or omissions are to be made, there usually arises a necessity of over-running; in order to which, they must decompose, or return the lines back from the chase into the galley, and from the galley again into the composing-stick, to be new-modelled and rectified accordingly.

If, *e. gr.* one or more words, to be inserted in a line, cannot be gotten in by changing the spaces of the line for lesser ones, part of the line must be put back into the close of the preceding one, or forward into the beginning of the subsequent one, or both, till room is obtained. If the insertion be large, several lines will need to be over-run, either backward or forward, till a break is arrived at; when if it be not gotten in, a line is to be driven out; and, to get in that line, the next pages, either backward or forward, must sometimes be over-run before it can come in.

When an omission is to be made, the contrary course must be taken. If it be but little, the compositor takes it out, and drives out the remaining matter, either by enlarging his spaces, or bestowing the beginning of the following, or the close of the preceding line therein. If it be considerable, he may be obliged to over-run several pages before it can be driven out.

As to the faults which escape the corrector and compositor, they are usually noted in what we call the *errata*. The ancient editions had no errata; but in lieu of it, they corrected the faults in each printed copy with a pen, which was easy enough in those days, though impracticable now. In effect, we have anciently had printers, who did not need an errata of above five articles in a volume of five hundred sheets; and the distinguishing excellence of printing is correctness; and in this respect many of our modern printers deserve much commendation.

Besides the several kinds of letters and characters above-mentioned, used in printing, they have likewise rules for black lines, borders, and head and tail-pieces, accommodated to the several kinds of letters.

The rules for black lines are of brass, and are made exactly of the height of the letter; otherwise they will hinder the neighbouring letters from printing, or will themselves be hindered by them. These the compositor occasionally cuts into proper lengths, as his work requires.

The *borders*, or *flowers*, are a kind of ornaments, in form of long bars, serving for the division of books, chapters, &c. Their depth is proportioned to the letter; and their length adjusted to the page; for being composed of several moveable pieces, it is easy to lengthen or shorten them.

The *head* and *tail-pieces*, cut either in wood, pewter, brass, copper, or silver, are compartments used at the beginnings and endings of books.

The initial letters are sometimes cut in wood, and figured; sometimes cast like the other characters.

For the conveniency of the binding, the printers had early recourse to signatures, *i. e.* letters of the alphabet placed at the bottom of the first page of each sheet, which shew the order they are to be bound in, as well as whether the quires are complete; which method is still continued.

The *catch-words* serve nearly the same purpose: these are the first words of each page, which are inserted at the bottom of the preceding pages. The number of the pages are equally serviceable to the reader and the binder, to guide to references, and to warrant the book duly bound and collated; some printers formerly put them at the bot-

toms of the pages; but custom has now carried it for the tops.

In the infancy of printing, they had likewise a registrum chartarum for the convenience of the binders: to draw this, at the end of each volume, they collected the signatures, and the first words of the first four sheets of each alphabet. To abridge it, they afterwards contented themselves to express the signatures, and how often each letter was repeated; but the registrum has been now long disused.

Pressman's office, or PRINTING, *properly so called.* To work off the form thus prepared and corrected by the compositor, there are three things required, paper, ink, and a press.

To fit the paper for use, it is to be first wetted or moistened, by dipping several sheets together in water: these are afterwards laid in a heap over each other; and to make them take the water equally, they are all pressed close down with a weight at top. As to the degree of wetting, it must be according to the quality of the paper, and the size of the letter; small letters, and stiff paper, requiring most wetting.

PRINTING *Ink* is of two kinds, black and red; the last occasionally used in title-pages, calendars, &c. the first for the body of books. The composition of each, though now reckoned no part of the printer's business, but usually furnished them by other hands, is as follows:

For black ink.—A hundred pounds of nut or linseed oil, being reduced, by boiling, to the consistence of a syrup, are cleansed and purified by throwing into them two pounds of coarse bread, and about a dozen onions. Nut-oil is supposed to be the best, and is accordingly preferred for the black ink, though the darker colour which it acquires from the fire makes it less fit for the red. This oil is boiled in an iron pot, capable of holding at least half as much more, because it swells very much; when it boils it is kept stirring with an iron ladle; and if it does not itself take flame, it is kindled with a piece of lighted paper, or burning wood, in order to increase its consistence and tenacity, and to diminish its greasiness. The oil is suffered to burn for half an hour or more; and the flame being then extinguished by covering the vessel close, the boiling is afterwards continued, with a gentle heat, till the oil appears of a proper consistence; in which state it is called varnish; of which there should be two kinds, one more and another less boiled; or a thicker and thinner, to be used for different purposes, and in different weathers. The oil is said to lose in being boiled into thick varnish from a tenth to an eighth part of its weight; but different oils, and perhaps the same oil in different states, differ in this respect. The design of adding the bread and onions is more effectually to destroy the greasiness; but Dr. Lewis doubts, whether additions of this kind are of much use. They then boil thirty or thirty-five pounds of turpentine apart, till such time as they find, upon its cooling on paper, that it breaks clean, like glass, without pulverizing; for if it pulverize easily, it is a sign it is burnt. The oil and turpentine being thus prepared, the first is gently poured, half cold, into the latter; and the two stirred together with a stick till they be well mixed: after which the boiling is repeated and the composition is set by, to be used occasionally. The turpentine is used in order to give a greater body to the varnish, and to increase its drying quality; and with some artists, litharge has in this intention been a secret. M. le Breton, in the Encyclopédie, observes, that when very old oil is used, neither turpentine nor litharge are needful; but that when the oil is new, some turpentine ought to be employed, because without it, the smearing of the paper, by the spreading or coming off of the ink, cannot be avoided; and he adds, that it is much more eligible to use old oil than to have recourse to this correction of the new: both turpentine and litharge, particularly the last, making the mixture adhere so firmly to the types, that it is scarcely to be got entirely off by the ley, whence the eye of the letter is soon clogged up.

Now to proceed to make ink, they take a quantity of this mixture, and add to it a certain quantity of lamp-black, working it up with a kind of wooden mallet, or braver, till the whole be incorporated, and reduced into a kind of pulp; which is the ink for use.

Where, note, that its thickness or strength is always to be proportioned to that of the paper, and the warmth of the weather; strong paper, and hot weather, requiring strong ink: and that the strength or weakness of the ink depends on the greater or the less degree of coction of the varnish. According to M. le Breton, two ounces and a half of the lamp-black are sufficient for sixteen ounces of the varnish. Lewis's Commerce of Arts, p. 371.

For red ink, they use the same materials as for black, excepting only, that instead of lamp-black, they add a proper quantity of vermilion. Some hold, that by mixing and incorporating the bigness of a nut of fish-glue, or brandy, or the white of an egg, with the ink, the vermilion acquires a greater lustre.

The PRINTING *Press* is a well contrived machine, and at a very early period of the art was brought to a degree of perfection, which has not admitted of any very material improvements till the present age. Who first invented it we are not informed, but from Mr. Moxon we learn, that it was very greatly improved by William Jansen Blaew, who established a printing-house at Amsterdam, where he printed many books and maps, which he made from the observations of the famous Tycho Brahe, who had for many years employed him as an assistant, and to make his instruments.

Fig. 1. *Plate* IV. *Printing*, is a representation of the printing press in perspective. It has two principal parts, each of which is composed of several others: the first is the body of the press, which is a frame containing the screw, and platen, or surface which produces the pressure upon the paper; and the other is the carriage, on which the *form* of types is laid, and has the means of being drawn out of the body of the press, to remove the paper when printed, and to substitute another sheet. For the convenience of changing the paper, the carriage is provided with frames, called the tympan and frisket, which fold upon each other and enclose the sheet between them, and are then again folded down upon the types.

The body of the press consists of two strong posts, *b*, *b*, placed perpendicular, called the cheeks, which are joined together by four horizontal cross pieces; the upper of these, *a*, is called the cap, and has no office but to retain the two cheeks at their required distances asunder: the next cross piece, *b*, is called the head; it is fitted by tenons at the ends into mortises between the cheeks, and these mortises are filled up with pieces of pasteboard or soft wood, in such a manner as to admit of a small motion or yielding. The head is sustained by two long screw-bolts, which suspend it from the cap: in the head is fixed a brass nut, containing a female screw or worm, which is fastened in the wood by two short bolts to keep it up: the worm is adapted to receive the screw by which the pressure is produced. The third cross piece, *e e*, called the shelves, or till, is to guide and keep steady a part, *i*, called the hose, in which the spindle of the screw (to be spoken of hereafter) is inclosed. The fourth cross plank, *f f*, called the winter, is fitted between the cheeks to bear the carriage;

it suftains the effort of the prefs beneath, as the head does above, each giving way a little, the one upwards the other downwards, to make the pull the eafier. The fpindle, *g g*, is an upright piece of iron, pointed at the lower end with fteel, having a male fcrew formed on its upper end, which enters about four inches into the female fcrew or worm fixed in the head: through the eye of this fpindle is fixed the bar or handle, *h*, by which the preffman works the prefs. The platen *k*, or furface which acts upon the paper to produce the impreffion, is fufpended from the point of the fpindle by means of a fquare block or frame of wood, *i*, called the hofe, which is guided by paffing through the fhelves *e e*: the lower part of the fpindle paffes through the hofe, and its point refts upon the platen *k*, being received into the plug fixed in a brafs pan fupplied with oil, which pan is fixed to an iron plate let into the top of the platen *k*. The preffman then, by pulling the bar *h*, fixed in the eye of the fpindle *g*, by an iron key turns the fpindle, and by means of its fcrew preffes down the platen upon the *form* of types, which is covered with the paper, tympan, and its blankets, all thefe parts being brought under the platen by the carriage, when the impreffion is to be given. That the platen may be fufpended from the fpindle, and rife up again with it, the hofe, *i*, is attached to the fpindle by the *garter;* this is a fillet of iron fcrewed to the hofe, and entering into a nick or groove formed round the upper part of the fpindle; it prevents the hofe falling down on the fpindle. At each corner of the lower part of the hofe there is an iron hook faftened, and from thefe to fimilar hooks, faftened at each corner of the platen *k*, cords or packthread are looped to fufpend the platen, and they are exactly adjufted, to hang the platen truly level.

The carriage *l l*, which is the other principal part of the prefs, is adapted to run into the fpace between the cheeks under the platen. It is fupported upon the ribs *n*, which are part of a horizontal wooden frame, having its fore-part fupported by a wooden prop *m*, called the fore-ftay, while the other end refts on the winter. On the rails of this frame two long iron bars or ribs are nailed, and under the plank of the carriage are nailed fhort pieces of iron or fteel, called cramp irons, which flide upon the ribs, when the carriage is run in or out, by the following means. Beneath the carriage is placed a fmall fpindle called the fpit, with a double wheel formed in the middle of it, round which leather girts are paffed and faftened, the oppofite ends being nailed to each end of the plank, *l*, of the carriage. On the extreme end of the fpit is fixed the handle or rounce *p*, by which the preffman turns the fpit, and this, by means of the wheel and ftraps, runs the carriage in or out at pleafure. The carriage itfelf confifts of a ftrong wooden plank *l*, upon which a fquare frame of wood is fixed, to form the coffin or cell, in which a marble or polifhed ftone is inclofed, for the form of the types to be laid upon. To this coffin are faftened leather ftay-girts, one to each fide, which being at the oppofite ends faftened to the cheeks of the prefs, prevent the carriage running too far out, when drawn from under the platen. On the fore-part of the plank is a gallows *r r*, which ferves to fuftain the tympans, when turned up from off the form, on their hinges. The tympans, *s*, *s*, are fquare frames covered with parchment. The frames are made of three flips of very thin wood, and at the top a flip of iron, ftill thinner, called a head-band. The two tympans are fitted together by the frame of one, being fmall enough to lie within the other: the outward tympan is faftened with iron hinges to the coffin. Between the two parchments of the tympans two or three thickneffes of blankets are placed, which ferve to make the impreffion of the platen upon the furface of the letters more equal, as alfo to prevent the letters from being broken by the force of the prefs. The ufe of the inner tympan is to confine thefe blankets. The frifket, *t*, is a fquare frame of iron, made very thin, alfo covered with paper or parchment, and faftened to the head-band of the outer tympan by hinges: it folds down upon the tympan, to enclofe the fheet of paper between them, the parchment or paper with which the frifket is covered being cut out in the neceffary places, that the fheet, when placed between the tympan and frifket, and both together folded down on the form, may receive the ink from the types in the pages; but the frifket fheet keeps the margins clean. The tympan and frifket, when folded down, lie flat upon the form, and the carriage with them is run into the prefs; but when the fheet is to be taken out, the tympan is lifted up upon its hinges, and refts, as reprefented, in an inclined pofition againft the gallows *r*, before mentioned, at the back part of the carriage; then the frifket, *t*, is lifted up on its hinges, and fuftained by a flip of wood, *w*, hanging from the ceiling, whilft it continues open, to take out the printed fheets and put in others.

To regulate the margin, and make the lines and pages anfwer each other when printed on the oppofite fide of the fheet, two iron points are fixed to the middle of the wooden fides of the frame of the tympan, which make two holes in the fheet. Thefe holes are placed on the fame pins, when the fheet is returned for making an impreffion on the other fide, which is called the *reiteration*, and the pins are adjuftable, that they may make the impreffions of the oppofite fides exactly correfpond.

The ink is applied upon the form by balls, which are a kind of wooden cups with handles, the cavities of which are filled with wool, or hair, covered with fheep's fkin nailed to the wood. One of thefe the preffman takes in each hand, and applying them on the ink-block, to charge them with ink, he works them one againft the other, to mix and diftribute the ink equally; and, at laft, fmears over the form, by beating or dabbing them feveral times over the whole face of it; this leaves the form in a condition to be paffed under the prefs, with the moiftened paper laid on it.

To prepare the prefs for working, the parchment of the outer tympan, againft which the fheet is to be laid, is wetted till it is very foft, in order to render the impreffion more equable; the blankets are then put in, and fecured from flipping by the inner tympan. Then, while one preffman is beating the letter with the balls, covered with ink, taken from the ink-block, the other perfon places a fheet of paper on the tympan, turns down the frifket upon it, to inclofe it, keep the margins clean, and prevent it flipping; then folding the tympan down upon the form, and turning the rounce, *p*, with his left hand, he brings the form, with the ftone and carriage, (which altogether weighs about 300 lbs. weight,) under the platen; pulls the bar with the right hand, by which means the platen preffes the blankets and paper clofe upon the letter, whereby half the form is printed; then releafing the bar, he advances the form ftill forward into the prefs, by turning the rounce, and gives a fecond pull: now letting go the bar, he turns back the form, lifts up the tympans, and opens the frifket, takes out the printed fheet, and lays on a frefh one; and this is repeated, until he has taken off the impreffion for the full number of fheets the edition is to confift of. One fide of the fheet being thus printed, the form for the other is laid upon the prefs, and worked off in the fame manner; the fheet being fo difpofed, that the iron points fhall pafs through the holes already made in the fheet.

Sometimes it is required to cut the frifket afrefh, where

the ſecond ſide is to be more or leſs full of printing than the firſt, as is frequently the caſe at the beginning and ending of books, half pages at the ends of chapters, &c.

The number of ſheets of the edition being complete, the form is to be ſeparated : to reſtore the letters into the compoſitors' caſes, they firſt waſh it in a ſtrong ley, to take out the remains of the ink, ſcouring it with a bruſh, and then with fair water. This done, it is carried to a wooden frame to be unlocked, and the furniture, *i. e.* the ſticks and quoins, taken off, to diſengage it from the chaſe. Then the compoſitor, taking out ſeveral lines at once upon a little braſs ruler, replaces each letter in its proper box, to be again uſed in the remainder of the impreſſion; which laſt operation they call *diſtribution.*

The operations of the printing preſs, when conducted by an expert preſſman, are performed with a ſurpriſing rapidity; but the labour is very great. Two men take it by turns to *pull*, that is, work the preſs, and *beat*, or ink the types. Whilſt one workman is employed in pulling the ſheet, his comrade is diſtributing the ink on his balls, by firſt applying them to the ink-block, which is a ſmall ſhelf fixed up againſt one of the cheeks of the preſs, and has ink ſpread out upon it by the ſlice and *brayer*, which is a wooden muller to mix and grind the ink; then applying the balls together, and turning them round in his hands, whilſt the ſurfaces are rolled or dabbed againſt each other, the ink becomes equally diſtributed over them. By this time the preſſman having made the pull, and opened the tympan, the other inſtantly begins the beating, whilſt the preſſman gets the ſheet changed. In beating, he holds a ball in each hand, and applies them upon the types, with the handles in an inclined poſition; and then he mounts the handles perpendicular, by which means the leather is rolled over the ſurface of the types, and they are effectually inked; but if they were moved in any other way, the hollows would ſcrape off the ink, and clog up the letters. Having thus inked a ſpace of as much extent as the two balls will conveniently cover, they are lightly lifted off the letters, and removed to another part, which is inked in the ſame manner, till the whole ſheet is gone over.

The preſſman, during the beating, has removed the printed ſheet, and laid another evenly upon the tympan, which is done with great addreſs; then folding down the friſket upon it, and ſhutting both together down upon the form, he runs in the carriage as before-mentioned, to take the firſt pull; for the platen being only half the ſize of the ſheet, it is printed at twice, and the firſt time the carriage is run into the preſs, the preſſman knows by a chalk mark previouſly made on the carriage when the firſt half of the ſheet is under the platen; he now makes his pull, and letting the handle go back, runs the carriage in again, till the other half of the ſheet comes under the platen, and then makes a ſecond pull. In this operation he leans his body back, and places his foot againſt a foot-board beneath the preſs, to gain a greater purchaſe. Preſſes are, in general, adapted for the ſcrew to make a ſufficient preſſure by a quarter turn of it, but this the preſſman can vary to his own inclination, by packing up the head, *b*, of the preſs with pieces of paſteboard in the mortiſes, till it yields as much as he requires for a *long pull;* or if he puts blocks of wood to fill up the mortiſes, it will make a *ſhort pull*, which has much the advantage of the other, in reſpect to the total exertion it requires; but then the handle being ſuddenly checked on coming to the preſſure, it gives a ſhock to the whole body, which few men can bear. Strong men will work beſt with a ſolid preſs.

The ſevere labour of printing, by the ordinary preſs, has, for a long time paſt, rendered it very deſirable to obtain an acceſſion of power. Many attempts have been made to produce a preſs which would print the whole ſurface of a ſheet at a ſingle pull: the firſt which has come to our knowledge was brought from France many years ago, and was called the Apollo preſs. It was a wooden preſs of the ordinary conſtruction, except that the platen was compoſed of an iron plate inſtead of a wooden plank, and made ſufficiently large to print the whole ſheet at once: the under ſurface of it was covered with braſs, and made truly flat. The ſcrew, or ſpindle, inſtead of being turned by the bar or handle, in the uſual manner, was united, by connecting rods, with a long lever, placed at the ſide of the preſs, and the man worked it by applying both hands to the lever, to bring it down nearly by the ſame action as working the lever of a pump; this action, requiring a motion of the whole body, was found intolerably fatiguing, and in conſequence they were ſoon diſuſed, even for printing newſpapers, where expedition is a ſuperior conſideration to every other.

Among the contrivances we have met with for improved printing preſſes, the firſt which has been ſucceſsful in a long courſe of practice, was invented many years ago by Mr. Roworth, a printer in London. Inſtead of the ſcrew he uſes a plain vertical ſpindle, furniſhed with a bar, hoſe, &c. juſt as uſual; but the upper part, where the worm is uſually cut, is a plain cylindric ſpindle, and fits into a ſocket fitted into the head of the preſs. Upon the upper end of the ſpindle, juſt beneath the head, a ſhort croſs arm is fixed, which acts againſt a circular inclined plane fixed under the head of the preſs; therefore, by turning the ſpindle, the croſs arm acts againſt the under ſide of the circular inclined plane, and cauſes the ſpindle to deſcend in the ſame manner as the ſcrew, but with this advantage, that the inclined plane is formed with a rapid deſcent at the time the action firſt begins; but when the platen has come down to the tympan, and the preſſure begun, the plane has a very ſlight inclination, and therefore a great power to produce the impreſſion; and this power increaſes as the reſiſtance increaſes. Still, from the manner in which the platen is firſt brought down, there is not, on the whole, that correſponding loſs of time which takes place in the uſual mechanical combinations for producing a great power. A great advantage is alſo derived in the working of this preſs, from making the inclined plane and croſs arm of hardened ſteel.

The Stanhope preſs, which is now becoming general, has this property in a higher degree, and is therefore capable of printing a double ſurface to the common preſs, with a very ſmall portion of the power which that required.

A Stanhope preſs is delineated in *Plate* I. *Printing*, *figs.* 1 and 2 being elevations, and *fig.* 3 a plan. A A is a maſſive frame of caſt iron, formed in one piece: this is the body of the preſs, in the upper part of which a nut is fixed for the reception of the ſcrew *b*, and its point operates upon the upper end of a ſlider *d*, which is fitted into a dovetail groove formed between two vertical bars, *e*, *e*, of the frame. The ſlider has the platen, D D, firmly attached to the lower end of it; and being accurately fitted between the guides *e*, *e*, the platen muſt riſe and fall parallel to itſelf when the ſcrew, *b*, is turned. The weight of the platen and ſlider are counterbalanced by a heavy weight, E, behind the preſs, which is ſuſpended from a lever F, and this acts upon the ſlider to lift it up, and keep it always bearing againſt the point of the ſcrew. At G are two projecting pieces, caſt all in one with the main frame, to ſupport the carriage when the pull is made; to theſe the rails, H, are ſcrewed, and placed truly horizontal for the carriage, I, to run upon them, when it is carried under the preſs to re-

ceive the impreffion, or drawn out to remove the printed fheet. The carriage is moved by the rounce or handle K, with a fpit and leather girts, very fimilar to the wooden prefs. Upon the fpit, or axle of the handle K, a wheel, L, is fixed, and round this leather belts are paffed, one extending to the back of the carriage to draw it in, and two others, which pafs round the wheel in an oppofite direction, to draw it out. By this means, when the handle is turned one way it draws out the carriage, and by reverfing the motion it is carried in. There is likewife a check ftrap, *f*, from the wheel down to the wooden bafe, M, of the frame, and this limits the motion of the wheel, and confequently the excurfion of the carriage. The principal improvement of earl Stanhope's prefs confifts in the manner of giving motion to the fcrew, *b*, of it, which is not done fimply by a bar or lever attached to the fcrew, but by a fecond lever; *e. gr.* the fcrew, *b*, has a fhort lever, *g*, fixed upon the upper end of it, and this communicates by an iron bar, or link, *h*, to another lever, *i*, of rather fhorter radius, which is fixed upon the upper end of a fecond fpindle, *l*, and to this the bar or handle, *k*, is fixed. Now when the workman pulls this handle, he turns round the fpindle *l*, and by the connection of the rod, *h*, the fcrew, *b*, turns with it, and caufes the platen to defcend and produce the preffure. But it is not fimply this alone, for the power of the lever, *k*, is tranfmitted to the fcrew in a ratio proportioned to the effect required at the different parts of the pull; thus at firft, when the preffman takes the bar, *k*, it lies in a direction parallel to the frame, or acrofs the prefs, and the fhort lever, *i*, (being nearly perpendicular thereto,) is alfo nearly at right angles to the connecting rod *h*; but the lever, *g*, of the fcrew makes a confiderable angle with the rod, which therefore acts upon a fhorter radius to turn the fcrew; becaufe the real power exerted by any action upon a lever, is not to be confidered as acting with the full length of the lever between its centres, but with the diftance in a perpendicular drawn from the line in which the action is applied to the centre of the lever. Therefore, when the preffman firft takes the handle, *k*, the lever, *i*, acts with its full length upon a fhorter length of leverage, *g*, on the fcrew, which will confequently be turned more rapidly than if the bar itfelf was attached to it; but on continuing the pull, the fituation of the levers change, that of the fcrew, *g*, continually increafing in its acting length, becaufe it comes nearer to a perpendicular with the connecting rod, and at the fame time the lever, *i*, diminifhes its acting length, becaufe, by the obliquity of the lever, the rod, *h*, approaches the centre, and the perpendicular diftance diminifhes; the bar or handle alfo comes to a more favourable pofition for the man to pull, becaufe he draws nearly at right angles to its length. All thefe caufes combined have the beft effect in producing an immenfe preffure, without lofs of time; becaufe, in the firft inftance, the lever acts with an increafed motion upon the fcrew, and brings the platen down very quickly upon the paper, but by that time the levers have affumed fuch a pofition as to exert a more powerful action upon each other, and this action continues to increafe as the bar is drawn forwards, until the lever, *i*, and the connecting rod are brought nearly into a ftraight line, and then the power is immenfely great, and capable of producing any requifite preffure which the parts of the prefs will fuftain without yielding. The handle is fometimes made to come to reft againft a ftop, which prevents it moving further, and therefore regulates the degree of preffure given upon the work: but to give the means of increafing or diminifhing this preffure for different kinds of work, the ftop is made moveable to a fmall extent. A better plan is adopted by fome makers of the Stanhope prefs, *viz.* to have a fcrew adjuftment at the end of the connecting rod *h*, by which it can be fhortened; it is done by fitting the centre pin which unites it to the lever, *g*, in a bearing piece, which flides in a groove formed in the rod, and is regulated by the fcrew. This fhortening of the connecting rod produces a greater or lefs defcent of the platen, when the handle is brought to the ftop.

The carriage of the prefs in *Plate* I. is reprefented with wheels, *m*, *m*, beneath, to take off the friction of moving upon the ribs, H. Thefe wheels are fhewn at *fig.* 4, which is a fection of the fcrew and the platen, with the carriage beneath it; and *fig.* 5 is a plan anfwering to it. *Fig.* 6 is a figure of the carriage, inverted, to fhew the wheels; their axles, *n*, are fitted to fprings, *p*, and thefe are adjuftable by means of fcrews, *r*, fo that the carriage will be borne up to any required height. This is fo regulated, that when the carriage is run into the prefs, its lower furface fhall bear lightly upon the folid checks, G, which are part of the body of the prefs, and thefe fupport it when the preffure is applied, the fame as the winter of the old prefs: but the wheels by their fprings act to bear up great part of the weight of the carriage with the types upon it, and diminifh the friction, yet do not deftroy the contact of the carriage upon the ribs, becaufe this would not give the carriage that folidity of bearing which is requifite for refifting the pull. This is only at the time when the carriage is run into the prefs, becaufe as it runs out, the ribs on which the wheels run rife higher, and therefore the wheels fupport the whole weight. The manner in which the wheels run in rebates or receffes in the edges of the ribs, is fhewn at *fig.* 2. The carriage is made of caft iron, in the form of a box, with feveral crofs partitions, which are all caft in one piece, and though made of thin metal, are exceedingly ftrong: the upper furface is made truly flat, by turning it in a lathe. The fame of the platen, which is likewife a fhallow box: the flider, *d*, has a plate formed on the lower end of it, which is fixed by four fcrews upon the top of the platen, and thus they are united. At the four angles of the carriage, pieces of iron, *r*, (*fig.* 5.) are fcrewed on, to form bearings for the quoins or wedges which are driven in to faften the form of types upon it in the true pofition for printing. The tympan, P, (*fig.* 1.) is attached to the carriage by hinges, with an iron bracket or ftop to catch it when it is thrown back: the frifket, R, is joined to the tympan, and when opened out, refts againft a frame fufpended from the ceiling. The regifter points are the fame as before defcribed in the wooden prefs, and all the operations of working are exactly the fame. The iron frame, A, of the prefs is fcrewed down upon the wooden bafe, M, by bolts, which pafs through feet, *s*, projecting from the lower part of the iron frame. Another wooden beam is fixed into the former at right angles, fo as to form a crofs, which lies upon the floor. The ribs, H, for the carriage to run upon are fupported from the wooden bafe by an iron bracket, T.

The advantages of the iron preffes in working are very confiderable, both in faving labour and time. The firft arifes from the beautiful contrivance of the levers, the power of the prefs being almoft incalculable at the moment of producing the impreffion; and this is not attended with a correfpondent lofs of time, as is the cafe in all other mechanical powers, becaufe the power is only exerted at the moment of preffure, being before that adapted to bring down the platen as quickly as poffible. This great power of the prefs admits of a faving of time, by printing the whole fheet of paper at one pull, the platen being made fufficiently large for that purpofe; whereas, in the old prefs, the platen is only half

the ſize of the ſheet. In the Stanhope preſs, the whole ſurface is printed at once, with far leſs power upon the handle than the old preſs, when printing but half the ſurface. This ariſes not only from the levers, but from the iron framing of the preſs, which will not admit of any yielding, as the wood always does, and indeed is intended to do, the head being often packed up with elaſtic ſubſtances, ſuch as paſteboard, or even cork. In this caſe much power is loſt, for in an elaſtic preſs the preſſure is gained by ſcrewing or ſtraining the parts up to a certain degree of tenſion, and the effort to return produces the preſſure: now in this caſe, the handle will make a conſiderable effort to return, which, though it is in reality giving back to the workman a portion of the power he exerted on the preſs, is only an additional labour, as it obliges him to bear the ſtrain a longer time than he otherwiſe would. The iron has very little elaſticity, and thoſe who uſe them find it advantageous to diminiſh the thickneſs of the blankets in the tympan to one very thin piece of fine cloth; the lever has then very little tendency to return, and the pull is eaſy in the extreme, requiring very little more force to move it at the latter, than at the firſt part: indeed it is ſo different from the other preſs, that when an experienced preſſman firſt tries it, he cannot feel any of that re-action which he has been accuſtomed to, and will not believe, till he ſees the ſheet, that he has produced any impreſſion at all; and for many days after he begins to work at an iron preſs, he by habit throws back all the weight of his body in ſuch a manner, as to bring the handle up to its ſtop with a concuſſion that ſhakes his arm very much; and in conſequence moſt preſſmen, after a few hours' work, feel inclined to give up the iron preſs; but when they have once got into a new habit of ſtanding more upright, and applying only as much force as it requires, the labour of the pull becomes leſs than that of running the carriage in and out; and men who are accuſtomed to the iron preſſes only, would be ſcarcely able to go through the work of the old preſs.

The Stanhope preſſes have come very much into uſe, and many people are engaged in making them. The firſt of theſe are Meſſrs. Walker, of Oxford-ſtreet, who have the advantage of being aſſiſted by the inventor, earl Stanhope; they have a very good machine for turning the ſurfaces of the platen and carriage, ſo as to produce very accurate planes; which is a great advantage, as it permits a much thinner blanket than could otherwiſe be uſed.

Mr. De Heine has a patent for a Stanhope preſs, which anſwers extremely well: the only material alteration is, that he has ſubſtituted a ſpiral, or curved inclined plane, in place of the ſcrew, which is fixed to the head of the preſs; and a croſs arm properly formed, and fixed on the upper end of the ſpindle, which ſtands in place of the ſcrew, acts againſt the fixed inclined plane. The action is very nearly the ſame as the ſcrew, except that the ſurfaces admit of being made of hardened ſteel, and thus diminiſh the friction very much. The inventor of this for the common preſs was, as we have before mentioned, Mr. Roworth, but Mr. De Heine has combined it with the levers and iron frame of the Stanhope preſs. This Cyclopædia is printed by Stanhope preſſes.

Mr. Peter Kier, of Camden Town, has made ſeveral Stanhope preſſes of a very good conſtruction, the ſtrength of all the parts being very well proportioned, ſo that his preſſes are not more liable to break at one part than another. The ſlider, *d*, he has made in a very convenient manner, by boring out a cylindrical hole down the centre of the preſs with a boring machine, and into this a cylinder is accurately fitted, the platen being fixed on the lower end of it. To prevent it from turning round, a flat ſide is made to the cylinder, and a bar of iron is ſcrewed acroſs the two cheeks *e*, *e*, between which the hole is bored, and bears againſt the flat ſide of the cylinder. Another improvement is in the ſpindle *l*, to which the handle is affixed: this has a ſcrew cut upon the lower end of it, which is fitted into a nut, and thus, when it is turned round, the ſpindle riſes and falls a quantity equal to the deſcent of the ſcrew, *b*, in the ſame period. By this means, the connecting rod, *b*, always draws in an horizontal direction, whereas, in the other preſſes, one end remains at the ſame level, whilſt the other deſcends, in conſequence of which the joints wear irregularly. On the whole, Mr. Kier's improvements, though they do not conſtitute a feature of the invention, contribute much to the accurate performance and durability of the machine.

The form he has adopted for the frame, A A, is very judicious; that in our plate is unneceſſarily ſtrong, having been made at an early period of the invention, when, from being unacquainted with the full power of the levers, many of the preſſes were broken by the ſtrain, and ſome makers then determined to put in ſuch a maſs of metal, as to reſiſt the utmoſt efforts of a man at the handle; but being now better underſtood, they are made much lighter than in the one in our plate, and ſufficiently ſtrong.

Several Stanhope preſſes, that is, preſſes having levers to work the ſcrew, have been made in wood by Mr. Brooke, or altered from the old wooden preſſes; but though this is an improvement upon them, it is greatly inferior to the iron frame, which, for the reaſons we have given, has a ſhare in the ſaving of power.

Mr. Medhurſt, of Denmark-ſtreet, Soho, has produced a printing preſs of great merit, from its ſimplicity, and it has the ſame advantage, in point of power, as lord Stanhope gains by the compound levers. It is a common preſs in all its parts, but the platen is made the full ſize of the ſheet, and inſtead of a ſcrew, a plain ſpindle is employed: on the lower part of it, juſt above the bar, a circular plate is fixed, and affords ſteps for the points of two iron rods, which extend up to the head, and are there ſupported by their points entering ſockets. When the platen is up, theſe rods ſtand in an inclined poſition, although both the ends of them are at the ſame diſtance from the centre of the ſpindle; but when the ſpindle is turned by the bar, the circular plate, in which the lower points of the iron rods reſt, turns round in a circle, and the upper ends remaining ſtationary, they of courſe come towards a vertical poſition, in which motion the ſpindle and platen are forced to deſcend, in the ſame manner as though a ſcrew was employed; but this motion has every advantage of the Stanhope levers, or Mr. Roworth's preſs, without the friction of either, for the power increaſes as the reſiſtance increaſes, and when the rods come nearly parallel to the ſpindle, or into a vertical poſition, the power is immenſely great. We think a preſs of this kind, if made of iron, and with the other advantages of lord Stanhope's, would be much ſimpler, and rather better, becauſe the friction and wear are inconſiderable, if the points of the rods and their ſockets are hardened.

We have been ſhewn a model of a new kind of preſs invented by Mr. Ruthven of Edinburgh; it differs from others in the following circumſtances. The form of types, inſtead of being ſituated on a running carriage, is placed upon a ſtationary platform or tablet, which is provided with the uſual apparatus of tympan and friſket, with points, &c. to receive the ſheet of paper, and convey it to its proper ſituation on the face of the types, after they have been inked. The machinery by which the power for the preſſure is produced, is ſituated immediately beneath this tablet, and the

platen or ſurface which is oppoſed to the face of the types to preſs the ſheet of paper againſt them, can be brought over the types, and connected at two oppoſite ſides or ends with the machinery beneath the table. By this machinery it is ſo forcibly preſſed or drawn down upon the paper which lays over the types, as to give the impreſſion, which being thus made, the platen can be diſengaged from the machinery, and removed from off the types by a motion of the foot, to take out the paper and introduce a freſh ſheet.

The machinery for producing the preſſure is a combination of levers, actuated by a crank, or ſhort lever, turned by a winch or handle, to which the preſſman applies his left hand, juſt as he does in the preſent to the rounce or handle of the ſpit, the handle being placed in the ſame ſituation for that purpoſe. The levers beneath the table are well contrived to have the beſt effect in ſaving time, and producing an immenſe preſſure; for when the preſſman firſt takes the handle, it acts with but little advantage as to power upon the levers, and therefore brings the platen down very quickly upon the tympan. The levers have then aſſumed poſitions, in which they exert a more powerful action upon each other; and this action continues to increaſe until one of the levers and its connecting rod come nearly into a line, when the power is immenſely great, and capable of producing any requiſite preſſure. For faſtening the types upon the table, or what the printers call the making regiſter, inſtead of quoins or wedges being introduced at the angles in the uſual manner, ſcrews are fitted through pieces which are fixed to the ſides of the table; and between the points of theſe ſcrews the form of types is held ſteady upon the table, and may be adjuſted.

We have not had an opportunity of trying a large preſs of this kind, but think it promiſes ſo much in ſaving of power and time, as to deſerve a trial by printers. It avoids the moving of the heavy carriages with the form; for the platen need be but a ſmall portion of the weight of the loaded carriage; and further, it is adapted to be moved from off the types ſideways, and therefore has a leſs diſtance to move than the carriage in the ordinary preſs. The machinery is well contrived in all its parts, both for performance and ſtability, and is adapted to be made of iron, that it may have no yielding parts. It is far cheaper than the Stanhope preſs.

A PRINTING-*Houſe* is a place deſtined for printing, and fitted up for that purpoſe with preſſes, caſes, and other furniture.

The moſt conſiderable printing-houſes in the world are thoſe of the Louvre and Vatican. The firſt, begun under Francis I., was carried to its utmoſt perfection under Lewis XIII., by the care of cardinal Richelieu; and removed into the galleries of the Louvre by Lewis XIV.

The Vatican printing-houſe, called alſo the *Apoſtolical* printing-houſe, becauſe the pope's bulls, decrees, &c. are printed in it, was begun by Pius IV., and furniſhed with great magnificence by Sixtus V. See VATICAN.

Out of both theſe printing-houſes have come forth very beautiful and ſplendid editions of the ancient authors. The Vatican was the firſt that printed books in the Arabic language.

PRINTING, *Stereotype*, is a method of producing plates from moveable types, by forming a mould with them in plaſter of Paris, or any other fit ſubſtance, and in this mould caſting a metallic plate, which will have the ſame ſurface as the types had, and will print the ſame. Therefore, in this method the moveable types are not uſed to print from, (except for proofs to correct the errors of compoſition,) but are employed as a model or pattern to caſt the ſtereotype plates by which the impreſſion is to be printed. For the hiſtory and further particulars of this invention, ſee STEREOTYPE.

PRINTING *Machine*.—The immenſe number of books and newſpapers which are printed in this country, has rendered it deſirable to have machines for printing, which would throw off copies more rapidly, and without requiring ſuch exceſſive labour as the printing preſs does. For daily newſpapers in London expedition is the grand object, as the whole impreſſion (often as many as 6 or 8000 copies) muſt be printed between the hours of midnight, and eight or nine o'clock in the morning; and often, when there are important debates in parliament, they are not able to begin printing ſo ſoon as midnight.

The firſt attempts at printing machines were only to employ machinery for actuating a common preſs, and by the force of horſes, or ſteam-engine, to perform the part of the preſſman. We have ſeen a model of ſuch a machine, which printed very well, and with great rapidity, but was ſo complicated, that on a large ſcale it could not have been urged into motion ſo quickly as the preſſman can work; and in effect, when put to trial, it was found to employ one horſe inſtead of one man to work the preſs. In 1790, Mr. Nicholſon took out a patent for a machine to print by cylindrical rollers, the types being ſo formed with ſtems ſmaller at one end than at the other, that, when compoſed, they would form a cylindrical ſurface inſtead of a plane. Between a roller covered with theſe types, and another plain roller, the paper was to be paſſed, and thus receive an impreſſion: the ink was diſtributed by machinery. Mr. Nicholſon's machine anſwered very well for printing patterns upon calico, paper-hangings, or any other papers, where the ſurface of a ſolid roller could be engraved to print from; but the moveable types were not found practicable, and therefore the machine was inapplicable to book-printing.

A patent has recently been obtained by Meſſrs. Bacon and Donkin, for a machine which they publicly exhibited before the univerſity of Cambridge, and they are now making one for printing bibles and prayer-books at the univerſity. We have examined their machine at work, and found it to diſplay ſo much mechanical ingenuity, and to produce ſuch beautiful ſpecimens of printing, with a rapidity unequalled by any other means, that we have made a drawing of it. (See *Plate* III. *Printing*.) The invention conſiſts in adapting the types to be fixed upon, and form the ſurface of, a priſmatic roller, ſuch as a ſquare, pentagon, hexagon, octagon, or other figure, and mounting this in a frame, with the means of turning it round upon its centres; a ſecond roller is applied in ſuch a manner, that its ſurface will keep in contact with the ſurface of the types which are inked, and the machine being put in motion, the paper which is to be printed is paſſed through and receives the impreſſion. The types are inked by a cylinder, which is applied to revolve with its ſurface in contact with them. By this invention, the advantages of types between rollers are obtained, although the types are impoſed upon plain ſurfaces.

Plate III. *of Printing*, contains a perſpective view of a machine, the priſm, A, of which is ſquare in its ſection, and has the ordinary types or letter preſs applied upon its four ſides, and firmly attached to it. The pivots at the end of the axis of this priſm are ſupported in the frame B B, and it is cauſed to revolve, by a connection of wheelwork, D E and F G, from the winch and fly-wheel at H. The types upon its ſurface are cauſed to print upon the paper by means of a ſecond roller, I *i*, called the platen, placed immediately beneath the former, and its ſurface being formed

to a particular curvature, produced by four ſegments of cylinders, its circumference, when it turns round, will always apply to the ſurface of the types, and thus a ſheet of paper being introduced between them will receive the impreſſion. The ink is applied to the types by means of a cylinder, K K, placed above the priſm. It is compoſed of a ſoft elaſtic ſubſtance; and that its ſurface may always apply to the types, its ſpindle is fitted in pieces L, L, which moving upon an axis, *n*, permit the cylinder to riſe and fall, to accommodate itſelf to the motion of the types. The ink cylinder receives its ink from a ſecond cylinder, M M, which is called the diſtributing roller, alſo compoſed of a ſoft ſubſtance, and is ſupplied with ink by a third ink roller N N, which is made of metal, and extremely true. The ink is lodged in quantity againſt this roller upon a ſteel plate, O O, the edge of which, being placed at a very ſmall diſtance from the circumference, permits the roller, as it revolves, to carry down a very thin film of ink upon its ſurface, and this being taken off by the diſtributing roller, is applied to the ſurface of the inking cylinder, which, as before-mentioned, inks the types.

The ſheet of paper is introduced, as ſhewn in the figure, by placing it upon a blanket, which is extended upon a feeding-board P P, and drawn into the machine at a proper time, by having a ſmall ruler, 2, fixed to it. The ends of this are taken forward by two ſtuds, *b*, attached to endleſs chains, which are extended from the wheels, *e*, *e*, at the end of the platen, to other wheels, *d*, *d*, which are ſupported in the frame of the feeding-board. The wheels, *e*, *e*, having teeth entering the links of the chains, cauſe them to traverſe when the machine is turned round, and at the proper time the pins, *b*, draw the ruler, 2, and blanket forward, and introduce the paper into the machine, and by paſſing between the priſm and platen, it is printed as before-mentioned. This is the general action of the machine, and we ſhall proceed to detail the ſtructure of the ſeveral parts. The type is compoſed, and made up into pages, in the uſual manner; the pages are then placed in frames or gallies, *a*, *a*, and faſtened by the ſcrews at the ends, the ſhape and ſize of the gallies being adapted to the ſize of the page it is intended to print. Theſe gallies are attached to the four ſides of the central axis of the priſm by the ſcrew-clamps 1, the edges of the gallies being mitred together. By relieving the clamps the gallies can quickly be removed, and others put in their places. The platen, I *i*, is compoſed of four ſegments of cylinders, *i i*, which are attached to the different ſides of the central axis, I, by means of ſcrews, and theſe ſegments being proportioned to the priſm, will be the true figure for the platen to produce the required motion, ſo that the ſurface, when it revolves, will, in all poſitions, preſerve an accurate contact with the ſurface of the types. The two wheels, D, E, which cauſe the priſm and platen to accompany each other, are formed to correſpond with the two. Thus the upper wheel, D, is a ſquare, with its angles rounded off, and the pitch or geometrical outline is exactly of the ſame ſize as the ſquare formed by the ſurfaces of the types. The lower wheel, E, is of the ſame ſhape as the platen, and its pitch line the exact ſize of the ſurface thereof. Theſe wheels being cut into teeth, as the figure ſhews, will turn each other round, and make their ſurfaces at the point of contact exactly correſpond in their motions, ſo as to have no ſliding or ſlipping upon each other. To regulate the preſſure upon the paper, the bearings in which the pivots of the platen are ſupported, can be elevated by ſcrews, 3, and its ſurface will preſs with more force upon the types; but that this may not derange the action of the wheels, D and E, univerſal joints are applied in their axles at R. The inking c K, is cauſed to preſerve its proper diſtance from the centre of the priſm by wheels, S, fixed upon its axis, and reſting upon ſhapes, T, fixed upon the axis of the priſm. Each of the ſhapes, like the wheel D, has four flat ſides, correſponding in ſize with the ſurfaces of the types; the angles are rounded to ſegments of a cirlce from the centre: the wheels, S, are of the ſame ſize as the inking cylinder, therefore, as they reſt upon the ſhapes, T, they prevent the ink cylinder preſſing upon the types with any more than a ſufficient force to communicate the ink without blotting. The inking cylinder is turned round by a cog-wheel, V, upon the extremity of the axis of the priſm, which is of the ſame ſhape as the wheel, D, and engages another wheel, W, upon the end of the ſpindle of the inking cylinder: the latter wheel likewiſe gives motion to the diſtributing roller by a pinion, *f*, and this again turns the ink roller by a third pinion, *g*, fixed upon the end of its axis, *n*, which is ſupported upon bearings, B, B, in the frame. The pieces, L, L, which ſupport the pivots of the diſtributing roller and inking cylinder, are fitted upon the axis, *n*, of the inking cylinder, ſo as to riſe and fall upon its centre, and the diſtances of the rollers being thus kept invariably the ſame, their circumferences are kept accurately in contact, to communicate the ink to each other. The ſteel plate, O, which, as before-mentioned, regulates the quantity of ink that the roller, N, ſhall take round with it, is ſupported by a piece extended acroſs the fixed frame, B B. There are pieces of metal fixed upon this plate by thumb nuts, which prevent the ink flowing off at the ends, and they enter into grooves formed round the ink roller, N, near its ends. The machine is put in motion by the handle with the fly-wheel H, and this has a ſmall wheel, G, turning a large one, F, upon the end of the axis *l*.

The frame ſupporting the feeding-board, P, conſiſts of two rails, X, fitted upon the axis of the platen, and ſupported at the oppoſite ends by a brace from the framing; they ſuſtain the pivots of the wheels, *d*, *d*, for the chains; *x* are two rulers fixed at each ſide of the feeding-board, and forming a lodgment for the ends of the ruler 2, which is attached to the blanket, and it ſlides upon theſe when it is advanced by the chains. The ſpaces on the platen between the ſegments, *i*, *i*, are all filled up by pieces of wood, except one, and in this ſpace the ruler is received when it paſſes through the machine. In the interval when the ſpaces between the types are paſſing over the ſheet, and therefore leave the margin between the pages of printing, the paper is not held between the rollers; but to prevent it from ſlipping during this interval, the blanket and paper are preſſed down upon the pieces of wood which fill up in the platen between the ſegments, *i*, *i*, by the weight of ſmall rollers or wires, 4, ſupported by cocks, 5, projecting from the axis of the priſm, and being fitted into the ſlits at the end of theſe cocks. The wires are at liberty to riſe and fall by their own weight; thus, when they are at the upper part of the revolution, they fall into the ſpaces at the angle of the priſm, between the pages of the types, and thus eſcape the ink cylinder; but when they are at the lower part of their revolution, they fall upon the paper, and preſs it with ſufficient force upon the pieces of wood in the platen to carry the paper forward at the interval when the types do not act upon it, and of courſe while the ſpace between the pages of the printing is paſſing through.

The operation of printing being very delicate, and requiring great accuracy, the machine is provided with many adjuſtments to make it act correctly, which are as follow: The ſegments, *i*, *i*, upon the platen roller are attached to the central axis, I, by three ſcrews at each end; the two

middle ones of these (represented with square heads) draw the segments down upon the central axis, whilst the others (which are turned by a screw driver) bear them off; therefore, by means of these screws, the segments can be accurately adjusted, till they are found by experiment to apply correctly to the types, and make an equal impression on all parts of the sheet. To render the whole impression greater or less, the screws, 3, beneath the bearings of the platen roller are turned as before-mentioned. The degree of pressure with which the ink roller bears upon the types, is regulated by increasing or diminishing the size of the shapes, T, which support its weight. And to render these capable of adjustment, each is composed of four pieces, marked 6, attached by screws, 7, to a central piece, or wheel, which is fixed upon the axis; and as the edges of these pieces form the outline of the shape, they admit of being adjusted by other screws to a greater or less distance from the centre, and of course may be made to bear up the ink cylinder, till the pressure on the types is equal throughout the whole surface, and sufficient to supply the ink properly. The ink cylinder is adjustable as to its pressure against the distributing roller, and for this purpose the bearings, *k*, which support the cylinder, are fitted upon the pieces, L, to slide, being capable of regulation by means of screws. In a similar manner the distributing roller can be adjusted to a proper distance from the inking cylinder. The plate, *o*, can be adjusted for the distance from the ink roller, N, by screws, *p*, fastened by thumb nuts: this regulates the degree of colour the impression will have, by permitting the roller, N, to take more or less ink: behind the inking cylinder, K, a rubber, or scraper, is placed, to press very lightly against the cylinder, and to prevent the ink accumulating, in rings, round the cylinder; it is fitted upon centres, and held up by a lever, which is suspended by a catch, *y*, at the end of the piece L. This catch is withdrawn when the machine is not at work, and then the scraper falling down upon its centre, does not touch the cylinder. It is necessary that the wheels D and E should be placed upon their axes, in such a position that their curvature will correspond with the curvature of the prism and platen. For this purpose the universal joint, R, is fitted upon the axis, *l*, of the wheel, with a round part, that it may turn on it. A piece of metal, *r*, is fixed fast upon the spindle, *l*, and has a hole in it for the reception of a tooth, *s*, which is screwed fast upon the universal joint; then two screws being tapped through the sides of the piece, *r*, press upon the end of *s*, and by forcing it either way, will adjust the wheel with respect to the platen, till they exactly correspond: another similar adjustment may be applied to the upper axis.

The manner of forming the inking and distributing rollers with an elastic substance, is worthy of particular notice. Leather stuffed in the manner of a cushion was first used, but did not succeed, because it became indented with the types; but after many trials, a composition of glue, mixed with treacle, was found to answer perfectly. The roller is made of a copper tube, covered with canvas, and placed in a mould, which is a cylindrical metal tube, accurately bored, and oiled withinside: the melted composition is then poured into the space of the mould, and when cold, the whole is drawn out of it, with the glue adhering to the copper tube, and forming an accurate cylinder without any farther trouble. The composition will not harden materially by the exposure to air, nor does it dissolve by the oil contained in the ink. This machine is well adapted to print from stereotype plates, which the universities have adopted for their bibles and prayer-books.

We understand that a printing machine will very soon be produced by Mr. Bensley, which is the invention of a foreigner, who has taken several patents for it, but we have not yet had an opportunity of seeing one.

Printing Machine for numbering Bank Notes.—This machine is ingenious and curious, from the circumstance, that after every impression which is produced by it, the types are changed by mechanism, so as to produce a different impression the next time. The Bank of England have, within these few years past, adopted this method of filling up the blank spaces which are left in their notes after they have been printed from a copper plate by the rolling-press. These blanks, which are for the number and date of the note, were formerly filled up in writing; for each note being different in these particulars did not admit of being printed, until the present machine was invented by Mr. Joseph Bramah. The note which is engraved on the copper plate, and printed, is as follows.

Bank of England, 1814.

I Promise to pay to Mr. Henry Hase or Bearer on Demand the Sum of Ten *Pounds*

Ten *For the Gov^r. and Comp^a. of the Bank of England.*

Upon these notes the machine is required to print the number twice repeated, which is first to be printed, in large characters, upon the word *I Promise*, in the first line, and again upon the words *or Bearer*, at the end of the same; as, for instance,

N° 13462

1814 *March* 11. *London* 11 *March* 1814.

London and the date are printed in the blank line which is left after the words, *sum of* Ten *Pounds*.

The copper plates on which the above is engraven are double, that is, each prints two notes upon one long piece of paper, which being put into the machine, has the blanks printed in the easiest manner imaginable. In the operation of taking out the paper to put in another note, the machine changes the types to the succeeding number: for instance, if one of the notes is printed N° 10 N° 10, and the other upon the same paper, N° 100 N° 100, when the paper is taken out, the types change, without any attention of the operator, to N° 11 N° 11, and N° 101 N° 101, and when these are printed, they change again to the succeeding numbers. The types for the date are cast in stereotype, and are of course changed every day, each machine being furnished with one for every day in the year.

The advantages of this method have been found considerable, in avoiding mistakes of numbering notes erroneously, to which they were before very liable, and in the dispatch of business, its advantages are very great. To fill up 400 notes, with the number and date twice repeated, was considered a sufficient day's labour for each clerk; but by the machines, one man can print 1300 double notes, which are equal to 2600 single ones, or perform more than six times the business which could formerly be done in the same time. The

Bank of England have more than forty of these machines, one of which we have obtained drawings from; but to diminish it to the size of a plate, our draughtsman has represented it as if cut in half, or made as a single machine, to print only one note at a time; those in use at the Bank are therefore to be considered as double the length, and containing a repetition of the types and the machinery for moving them. In *Plate* II. *Printing*, *fig.* 1. is a section, and *fig.* 2. a plan, and the same letters refer to both. The whole is framed upon a thick board of mahogany, which is fastened down upon a table: the frame, which is of iron, is screwed to the board at L, and forms a square box, in which the mechanism is contained. K K is a brass lid, or cover, to the box, through holes in which the types, for printing the numbers, are placed, and their surfaces project a little above the surface of the cover, K, so as to produce an impression when the note is pressed down upon them by the power of the hand applied to the lever D. This lever moves upon an axis A, (*fig.* 1.) which extends across the box, having pivots fitted into sockets, B, (*fig.* 2.) projecting up from the frame, as is evident in the figure. From this axis a piece of metal, C, extends, and has screws, *l* and *m m*, in it, by which the tablet, or platen, E, is attached to it; and these screws admit of adjusting the tablet, E, with respect to the axis, that its under surface may fall perfectly flat upon the types, and print with equal pressure upon all parts of the note. For this purpose four of the screws, *m*, pass through holes in the piece C, and screw into the tablet, so as to draw the two together; whilst the other two screws, *l*, *l*, screw into the piece C, and their points bear upon the upper surface of the tablet, E; it is therefore by the latter that the pressure is transmitted, the others being only for adjustment: the lever D D is fastened upon C by three screws, marked *n*, *o*, *o*. The note is placed upon the under surface of the tablet, E, when it is to be printed, its situation being determined by two fine pins fixed in the tablet, which are made to penetrate the paper at two small dots printed upon it by the copper-plate which printed the words of the note, as before-mentioned; and it is confined in its position against the tablet by the frisket, which is a piece of vellum, H, stretched in a brass frame, and is connected by hinges, *a*, *a*, to the tablet E; it thus folds down, enclosing the note between the tablet and frisket as it were in a book. The vellum of the frisket has openings cut through it at the places where the machine is to print upon the note. As it is necessary that the paper should be pressed upon the types by a yielding substance, the tablet, E, has two folds of cloth placed against its surface, and these are secured by a piece of parchment, stretched over a brass frame, which is attached to the tablet by four screws. The note therefore is placed against this parchment when it is to be printed; and not against the brass of the tablet. Each circle, as shewn in *fig.* 6, has its circumference divided into 11 cogs, and in every cog a space is cut to receive one of the types which are arranged round the cogs, in a series of 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, and a blank; and as the circles are placed close together, and turn round independent of each other, any combination of figures may be made by them which is less than N° 99,999, beyond which number the bank-notes have not extended. Each of the circles has a tendency given it to assume the position in which the types are proper for printing; that is, with their upper surface parallel to the brass plate K, by means of a small pin fitted into a hole in the axis F, and having a constant pressure outwards by a small spiral spring placed in the hole beneath it. This pin comes to rest in an angular notch made withinside the circle, opposite each type, as shewn by the dark shaded parts in *fig.* 6, and each circle is provided with one of these pins. The end of the pin is formed spherical, and well polished, so that when the circle is turned round, it is forced into its hole in the axis F; but when another notch in the circle presents itself, the pin presses out into it, and retains the circle with a moderate force in its proper position, but will not allow it to rest, except when the pin is in the notch. The word London and the dates are cast in stereotype, and are fastened down upon the surface of the cover, K, of the box, just beneath the letter E, in *fig.* 1. The dates are changed every day; the catch, by which they are fastened on the plate, being very readily withdrawn; but when thrown up, holds them sufficiently fast. The types for printing the numbers are moveable, and herein the invention consists; they are fixed in the circumferences of wheels, or circles, *d*, *d*, (shewn also at *e*, *e*, in *fig.* 3, where the types are plainly pointed out by the numerals upon them); these circles are ten in number, and are divided into two clusters, one at each end of the spindle, or axis, F, upon which they all revolve freely. This axis, when in the machine, as at F, (*fig.* 1.) extends across the frame from side to side, and the types fixed in the circles project above the surface of the cover, K, passing up through holes made in the same, as is evident from the figure. By this means the types always arrange themselves into a straight line, and also with their surfaces parallel to the surface K K, without which they would not print equally upon the paper. From this description, our readers will perceive that the machine has the power of printing any numbers, or series of numbers, containing less than five figures, by turning the circles round one tooth every time after an impression has been taken, so as to bring a succeeding type into action. But the machine is rendered very complete, by the addition of the following mechanism, to give motion to the circles. A catch or click, *b*, is fixed upon the axis, A, of the platen, and acts in the teeth of a wheel, H, fixed upon an axis, G, (see also *fig.* 4.) which is extended across the machine, and the teeth of other similar wheels, H and K, (*fig.* 4.) enter into the spaces between the types in the circles *d*, *d*, as seen in *fig.* 1, and thus, when the axis, G, is turned round, it communicates a corresponding motion to some of the circles. The click, *b*, is fixed on the axis, A, in such a position, that it does not operate upon the teeth of H, except when the handle, D, is lifted up, or rather thrown back, as far as it will go, which is regulated by pieces screwed upon the axis coming in contact with the stops fixed upon the plate K; and in doing this, the catch, *b*, moves the wheel, H, round one tooth, and consequently the wheel *d*, so as to bring up another type.

The operator, in using the machine, first inks the types with a small printer's ball, opens the frisket sheet, H, upon its hinges, *a*, and places the note against the tablet, the proper place being determined by the dots and pins before-mentioned. He now shuts up the frisket, and encloses the note between it and the tablet, the frisket sheet having holes cut through it at the places where the note is to be printed. The handle, D, is now brought down to give the impression; but in this, it should be observed, that though the catch, *b*, again meets the tooth of the wheel H, it has no effect upon it, being fitted upon a joint, so as to give way in this direction, and it passes by without moving the wheel. The pressure for printing is given in an instant, and the handle, D, being then lifted up to remove the note, and place a fresh paper upon the tablet, the catch, *b*, moves the wheel, H, one tooth; and as these engage the teeth of

the circles, *d*, they are turned likewise to change the types ready for printing the succeeding numbers.

We have now to explain the order in which the change of the numbers is conducted. The wheels, H and K, (*fig.* 4.) are only intended to operate upon one of the five circles at the same time; but by sliding the axis, G, endways in its bearings, they can be made to act upon any one of the five which is required; and in all cases the distance between the two wheels, H and K, is such, that they will operate upon the same circle of the assemblage, at either end at the same time. The axis, G, can be retained in any required position by a semi-circular clip, which enters into grooves, *e*, (*fig.* 4.) formed round the axis, and there are five of these, corresponding with the different positions of the axis proper for the wheels to act with the several circles. The shifting of the axis is performed by the knobs at the ends of the spindle, G, which come through the sides of the box, the semi-circular clip which retains it being first lifted up, by turning a knob, *k*, which operates upon it. When the printing first begins, the circles, *d*, are turned round by means of a wooden skewer, so that all the blank types are brought up at the same time. The axis, G, is next set, so that its wheels, H and K, are engaged with the right-hand circle of each of the assemblages of five at each end. In this situation, if the handle, D, is moved down, in raising it up again, the catch, *b*, moves the wheels round, and brings up N° 1 N° 1 of the types, and a note being printed with this, in lifting up the handle N° 2 is brought up. Another note is now printed, then N° 3, and so on, till N° 9 is printed, and 0 brought up; after which, the handle is brought down twice without printing any note. This brings up the blank space and N° 1. The axis is now shifted by its knob Q, (*fig.* 1.) to act upon the second circle from the right-hand, and one motion of the handle being made, brings up 0 of the second circle, making 01 °N, which, when printed, (types being always in reverse,) will be N° 10. The first circle to the right-hand, which before was units, is now become tens, and the second units, which therefore shifts, at every impression, to 11, 12, &c. up to 19; and after printing this the 0 comes up, making 10. The first right-hand circle is then pushed forwards by the printer by a small wooden skewer, and 2 brought up, making 20. In this manner it proceeds, changing the first circle by hand at every ten, the machine altering itself at every unit, till 99 are printed. When 100 is to be printed, the axis, G, is shifted to the third circle, which becomes units, the second, tens, and the first, hundreds. The printing then proceeds as before, the units being advanced by the machine, but the tens and hundreds, as often as they require it, are advanced by hand. At 1000 the axis is shifted to the fourth circle, and the denomination of each is changed by this becoming the unit: three circles must now be moved by hand, as often as they require it. On arriving at 10,000, the fifth circle must be made unit, by shifting the axis to it, and the four first are moved, when necessary, by hand, and in this manner the machine will print up to 99,999, which is 100,000, wanting 1.

Printing, *Chinese.* There are three opinions as to the antiquity of the Chinese printing: one fixing it three hundred years before Christ; another nine hundred years after him; and a third carrying it still farther back, and making it coeval with that mighty empire; though, it must be allowed, the last is much the least probable of the three.

The manner of printing we have already hinted to be very different from that which now obtains among the Europeans. It is true, it has some advantage over our's in correctness, and the beauty of the character; but, in other respects, it comes far short, the single advantage of moveable characters making more than amends for all that is urged against us by some zealous advocates for this oriental printing.

Books are printed in China from wooden planks, or blocks, cut like those used in printing of calico, paper, cards, &c. among us.

These blocks are made of a smooth, firm, close wood, and of the size of the leaf required. On the face-side they glue a paper, upon which some able penman draws out the several letters and characters with a Chinese pen, which is a kind of pencil. This is the principal part of the work, and that on which the success of the rest depends.

When finished, the block is put into the hands of a sculptor, or cutter in wood; who, following the several strokes of the writer with his gravers, and other sharp little instruments, makes them all appear in relievo on the wood. When the carving or cutting is finished, they moisten what remains of the paper, and rub it gently off.

The ink they use in printing is the same with the common Chinese ink, with which they also write, and is made of lamp-black, mixed up with other ingredients.

Their press resembles our rolling-press much more than the letter-press.

As to their paper it is inferior to our's: it is made of the inner bark or rind of a kind of rushes, beat up with water into a pulp or paste, and formed in moulds, much like our's. See Paper.

The advantages of the Chinese printing consist in this, that they are not obliged to take off the whole edition at once, but print their books as they need them; that the blocks are easily retouched, and made to serve afresh, and that there needs no corrector of the press.

Its disadvantages are, that a large room will scarcely hold all the blocks of a moderate volume; that the colour of the ink easily fades; and that the paper is apt to tear, and is subject to worms: whence it is, that so few ancient books are seen in China.

Printing, *Rolling-Press*, is employed in taking off prints or impressions from copper-plates engraven or etched.

It differs, as we have before observed, from letter-printing, in that the marks and characters, whose impressions are to be taken, in the former case are indented, or cut inwards; and in the latter are in relievo, or stand out.

This art is said to be as ancient as the year 1460, and to owe its origin to Finiguerra, a Florentine goldsmith; who, casting a piece of engraven plate in melted brimstone, found the exact print of the engraving left in the cold brimstone, marked with black licked out of the strokes by the liquid sulphur.

Upon this, he attempted to do the same on silver plates with wet paper, by rolling it smoothly with a roller; and this succeeded.

This novelty tempted Baccio Baldini, a goldsmith of the same city, to attempt the same; which he did with success, engraving several plates of Sandro Boticello's design, and printing them off in this new way; in which he was followed by Andrew Mantegna, then at Rome.

This knowledge getting into Flanders, Martin of Antwerp, a famous painter, graved abundance of plates of his own invention, and sent several prints into Italy, marked thus, M. C. After him, Albert Durer appeared, and gave the world a vast number of prints both in wood and copper. About this time, one Hugo de Carpi, an Italian painter, found out a way, by means of several pieces of wood, to make prints resemble designs of chiaro-scuro (see Cutting *in Wood*); a method revived in our country, some years ago, with much success by Kirkall, and since at Venice by

Jackson, though very imperfectly; and some years after, the invention of etching was discovered, which was soon after made use of by Parmeggiano.

Mr. Walpole observes, that it was not till Raphael had formed Marc Antonio, that engraving placed itself with dignity by the side of painting. See ENGRAVING and ETCHING.

When the art reached England does not certainly appear. Mr. Chambers, on the authority of Mr. Bagford, (see Phil. Transf. N° 310. p. 2397, or Abr. vol. v. part ii. p. 20.) erroneously said, that it was first brought from Antwerp by Speed, in the reign of James I.; whereas we had it in some degree almost as soon as printing; the printers themselves using small plates for their devices and rebuses. Caxton's Golden Legend, printed in 1413, has in the beginning a group of saints, and many other cuts dispofed through the body of the work. The second edition of his Game of Chess, and Le Morte de Arthur, had also cuts. Wynkyn de Worde, Caxton's successor, prefixed to his title of the Statutes, in the seventh year of Henry VII. or 1491, a plate with the king's arms, crests, &c. a copy of which is given in the Life of Wynkyn, by Mr. Ames, in his Typographical Antiquities, p. 79. The same printer exhibited several books adorned with cuts, some of which are particularly described by his biographer, p. 87, 88, 89, &c.

The subsequent printers continued to ornament their books with wooden cuts. One considerable work, published by John Rastell, called the Pastyme of the People, and Rastell's Chronicle, was distinguished by prints of such uncommon merit for that age, as to have been ascribed to Holbein. Grafton's Chronicle, printed in 1569, contained many heads, as of William the Conqueror, Henry VIII., queen Elizabeth, &c. and many more are recorded by Ames. But though portraits were used in books, Mr. Walpole observes, that he can find no trace of single prints being wrought off in that age. Those which composed part of the collection of Henry VIII. were probably the productions of foreign artists. The first book that appeared with cuts from copper-plates, or at least the first that Mr. Ames had observed, was the Birth of Mankind; otherwise called the Woman's Book, dedicated to queen Catharine, and published by Thomas Raynalde in 1540, with many small copper cuts, without any name. See Ames, ubi supra, p. 35. 46. 60, and 219. Walpole's Catalogue of Engravers, &c. 4to.

The fabric of the rolling-press, and the composition of the ink used in it, with the manner of applying both in the taking off prints, are as follow:

Structure of the Rolling-Press.—This machine, like the common press, may be divided into two parts: the *body* and *carriage*, analogous to those in the other.

The body consists of two cheeks of different dimensions, ordinarily about four feet and a half high, a foot thick, and two and a half apart, joined at top and bottom by cross pieces. The cheeks are placed perpendicularly on a wooden stand or foot, horizontally placed, and sustaining the whole press.

From the foot likewise rise four other perpendicular pieces, joined by other cross or horizontal ones; which may be considered as the carriage of the press, as serving to sustain a smooth, even plank, which is about four feet and a half long, two feet and a half broad, and an inch and a half thick; upon which the engraven plate is to be placed.

Into the cheeks go two wooden cylinders or rollers, about six inches in diameter, borne up at each end by the cheeks, whose ends, which are lessened to about two inches diameter, and called *trunnions*, turn in the cheeks between two pieces of wood, in form of half-moons, lined with polished iron, to facilitate the motion.

The space in the half moons, left vacant by the trunnion, is filled with paper, pasteboard, &c., that they may be raised and lowered at discretion; so as only to leave the space between them necessary for the carriage of the plank charged with the plate, paper, and blankets.

Lastly, to one of the trunnions of the upper roller is fastened a cross, consisting of two levers, or pieces of wood, traversing each other. The arms of this cross serve in lieu of the handle of the common press; giving a motion to the upper roller, and that to the under one; by which means the plank is protruded, or passed between them.

Preparation of the Ink.—The ink used in rolling-press printing, is a composition of black and oil mixed and boiled together in a due proportion.

The black is a factitious matter, made, as some suppose, of the oil of vine twigs, or, according to others, of the kernels of fruits, such as peaches and apricots, well burnt, with wine lees.

This black is usually brought hither ready prepared from Frankfort on the Maine; whence our printers call it Frankfort black.

This is softer and more free from grittiness than the ivory or other charcoal blacks, as they are usually prepared among us.

The oil with which they dilute this black is nut-oil; which is set on fire, boiled up differently, according to the different works it is to be used in; but never so far as to communicate to the oil the adhesive gluey quality of the printer's varnish.

They usually make three kinds, thin, thick, and strong, only differing in the degree of coction; the strong is that used in the finest works, &c.

To make the ink, they pulverize the black very carefully, and pass it through a fine sieve; then mix it up on a marble with the proper oil, by means of a mullet, after the same manner as the painters do their colours.

PRINTING *from Copper-plates, Method of.*—The ink being prepared, they take a little quantity of it on a rubber, made of linen rags, strongly bound about each other; and with it smear the whole face of the plate, as it lies on a grate, over a charcoal-fire.

The plate sufficiently inked, they first wipe it coarsely over with a foul rag, then with the palm of the left hand, then with that of the right; and to dry the hand, and forward the wiping, rub it from time to time on whiting. In wiping the plate perfectly clean, yet without taking the ink out of the engraving, consists a great part of the address of the workman. The French printers use no whiting, as being detrimental to the colour of the ink; nor do they lay the plate on the grate to warm, till after inking and wiping it.

The plate, thus prepared, is laid on a thick paper, fitted upon the plank of the press; over the plate is laid the paper, first moistened, to receive the impression; and over the paper two or three folds of blanketing, or other stuff.

Thus disposed, the arms of the cross are pulled, and, by this means, the plate, with its furniture, passed through between the rollers; which, pinching very strongly, yet equably, presses the moistened paper into the strokes of the engraving, whence it licks out the ink.

Some works require being passed twice through the press, others only once, according as the graving is more or less deep, or the greater or less degree of blackness the print is desired to have.

It muft be obferved, that the ftronger and thicker the ink is, the ftronger muft the rollers pinch the plate; this tempts many of the workmen to ufe a thinner oil, in order to fave labour; which proves very prejudicial to the impreffion.

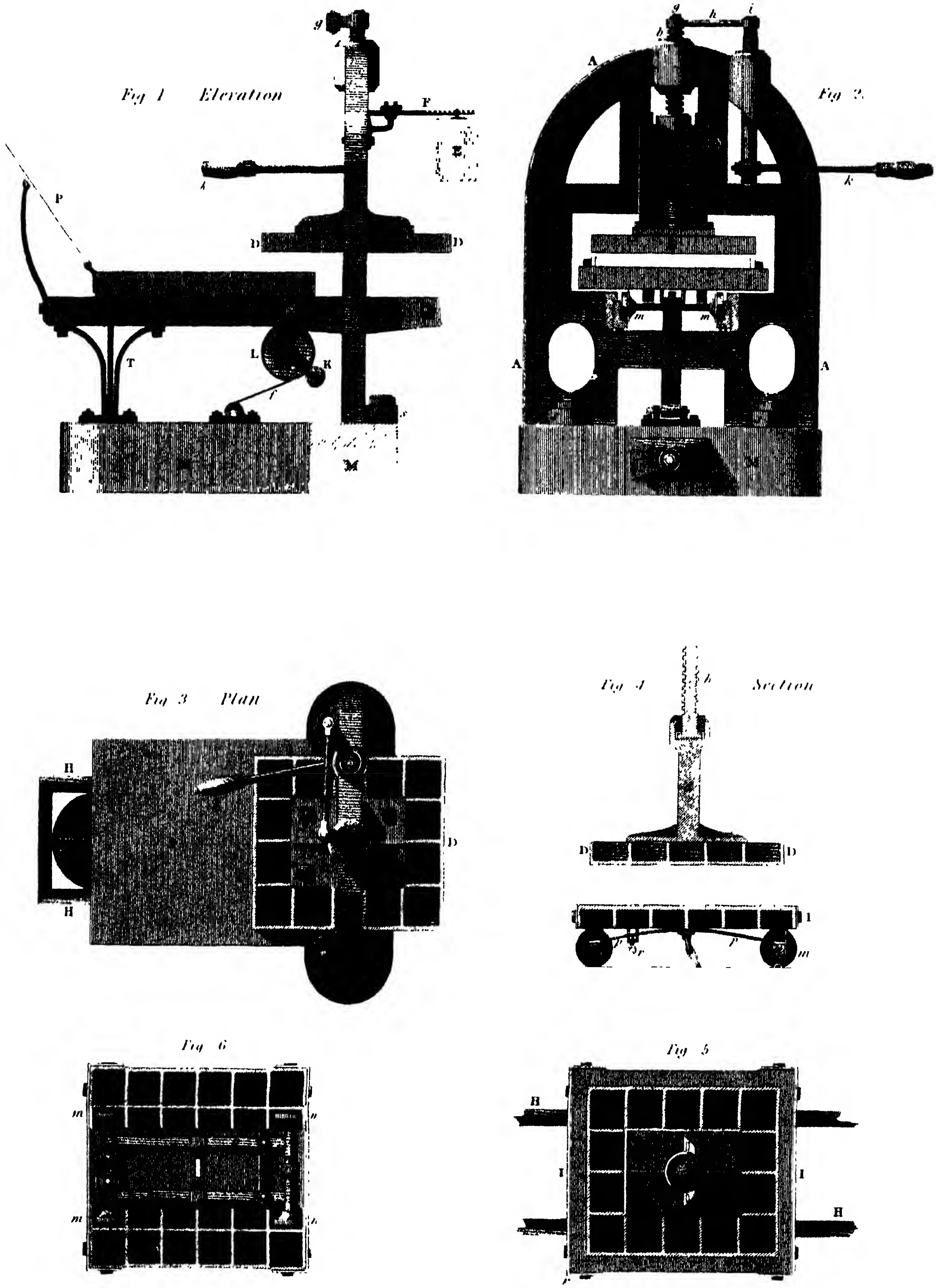
The wetting of the paper ought to be done two or three days before printing it, to render it more fupple and mellow: as the prints are drawn off, they are hung up to dry on lines, &c.

Laftly, after the number of prints defired have been wrought off from the plate, they rub it over with oil of olives, to prevent its rufting, and fet it by againft a new impreffion. If the ftrokes of the graving be perceived full of ink hardened therein in the courfe of the printing, they boil it well in ley before the oil be applied.

PRINTING *with wooden prints*. See CUTTING *in Wood*.

PRINTING *in chiaro-fcuro*, is a method of producing a ftrong effect of relief, attended with a juft and natural gradation of the lights and fhades, grounded with brown, with white and black, by printing on paper. We have already obferved, that the art of doing this in wood was difcovered in Italy, by Hugo de Carpi. M. le Boffe directs it to be performed in the following manner. Having provided two copper-plates of equal fize, and exactly fitted to each other, on one of them let the propofed defign be engraved, and let the prints be taken off from it with printing ink on fheets of grey paper. The other plate muft then be varnifhed, and the varnifhed fide being laid upon the fheet printed by the firft plate, they muft be paffed under the roller; when the print will have made a counter-proof on the varnifh of the plate; after which the lights muft be graved on the plate, and corroded very deeply by aqua-fortis. The fame thing may otherwife be done with the graver, and with greater eafe by thofe who can ufe it well. In order to properly prepare the oil, the beft method is to ufe very white nut-oil drawn without fire, and to put it into two leaden veffels, and fet it in the fun till it becomes thick in the proportion of the weak oil. Flake white muft then be taken, which muft be ground, and wafhed over, till it be extremely fine; and then being dry, it muft be ground with the weak oil, and the thick oil added to it. Then having taken an impreffion with black printing ink, or any other colour, from the firft plate, that is entirely engraved, on coarfe grey paper, it muft be left to dry for ten or twelve days; when thefe prints having been wet, another impreffion muft be made upon them by the plate, on which the lights are engraved, charged with the white flake and oil in the ufual manner of printing; taking care that the correfpondent parts of the plate, and the impreffion already made, may be adapted exactly. By this means the printing in chiaro-fcuro is perfectly performed. See CLAIR *Obfcure*.

The STANHOPE or IRON PRESS.

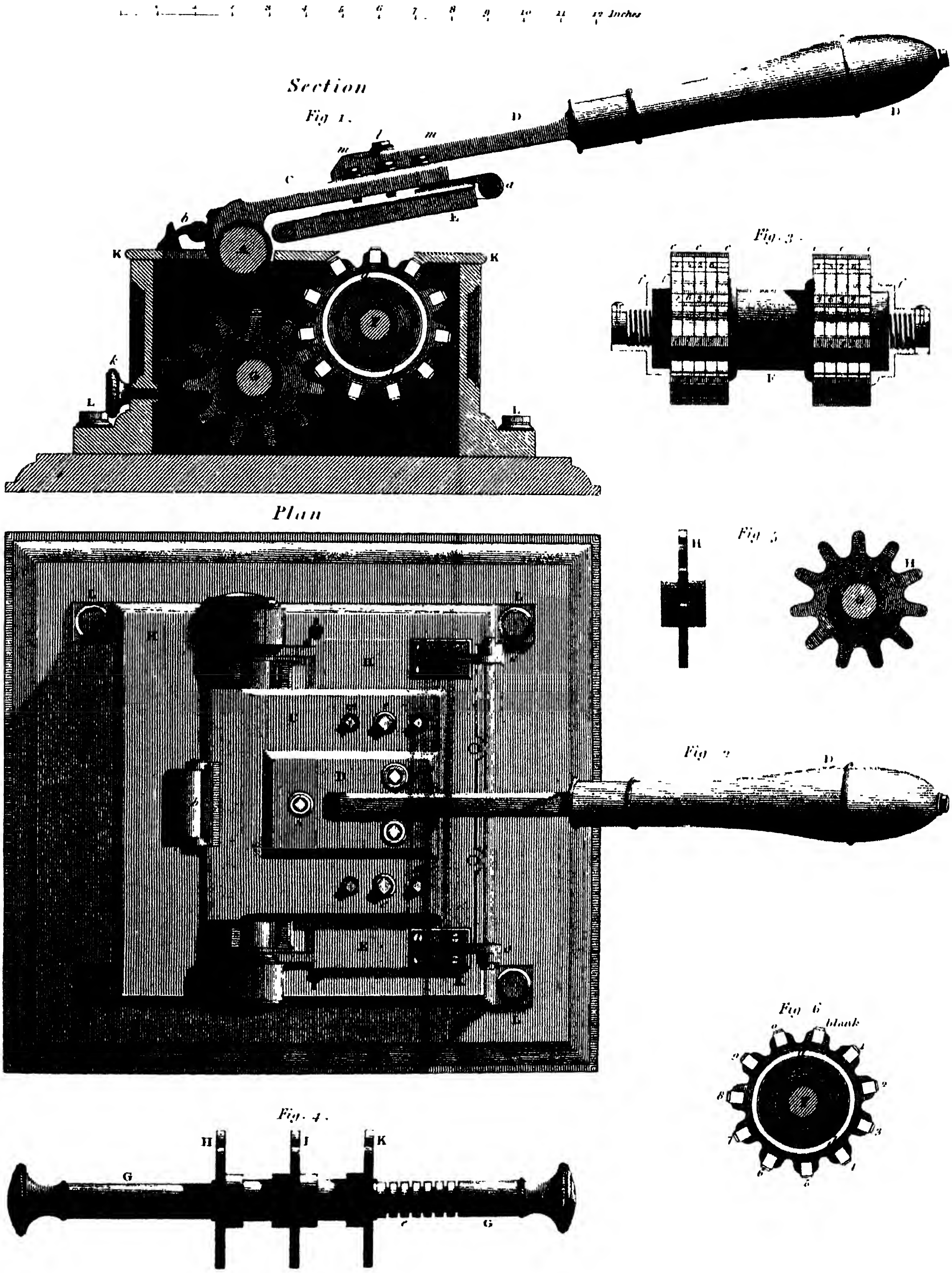


J. Farey delin

Published as the Act directs 1817 by Longman, Hurst Rees Orme & Brown Paternoster Row

PRINTING.

Mr. Bramah's Bank note Printing machine.



J Farey delin.

Published as the Act directs, 1812 by Longman Hurst Rees Orme & Co Paternoster Row.

Engraved by W. Le

Pump

PUMP, Antlia, in *Hydraulics*, a machine formed on the model of a ſyringe, for raiſing of water.

Vitruvius aſcribes the firſt invention of pumps to Cteſebes the Athenian; whence the Latins call it *machina Cteſebiana*, or *organum Cteſebicum*.

Pumps are diſtinguiſhed into ſeveral kinds, with regard to the ſeveral modes of their acting. As the

Common ſucking-pump, which conſiſts of a pipe open at both ends, in which is a moveable piſton, bucket, or ſucker, as big as the bore of the pipe in that part in which it works, and leathered round ſo as to fit the bore exactly; and may

be moved up and down, without admitting any air to come between it and the pipe or pump barrel. There are feveral kinds of buckets: the moft fimple of all, which is commonly ufed for ordinary pumps, confifts of a cylindric piece of wood, whofe diameter is fomewhat lefs than the bore of the barrel, that it may move in it freely, having a hole quite through the middle of it. Upon the top of this there is an iron piece faftened to a rod of iron or wood, which goes quite to the top of the pump, and by means of which the motion is given to the bucket. Near the top of the cylindric wood, there is a leather ring faftened round it, which goes a little higher than its top: the hole in the wood is ftopped by a valve, made of a round piece of leather, faftened in one part of the wood with nails. Upon this there is an iron plate, a little larger than the bore of the hole, and another iron plate under it, a little lefs than the fame bore; and the plates and leather are faftened together by means of a rivet or fcrew in the middle of them. When the bucket is put into the barrel, and the leather becomes wet, it will apply itfelf to the fides of the barrel, and prevent the paffage of the air. The ufe of the two iron plates is to fuftain the preffure of the water which would otherwife bend the leathers. For larger pumps, the bucket is made in the following manner: there is a hollow piece of brafs, almoft equal at top to the bore of the barrel, but fmall at the bottom, having at its top a brafs bar, and at the bottom two notches to receive the ends of another brafs bar, of the fame figure as that at the top. Round the brafs piece there goes a leathern ring, faftened to it at its lower part by means of an iron ring, which, being almoft at the bottom of the brafs piece, is not fo large as its top, and confequently does not touch the fides of the barrel: this leathern ring fhould go a little higher than the crofs-piece at bottom. The valve confifts of a piece of leather almoft equal to the top of the brafs piece, covered by two iron plates of the fame fize as the leather, and having under it two plates fomewhat fmaller than the bore of the brafs piece at its top; thefe iron plates and leathers are faftened together with fcrews. This valve muft be applied to the top of the brafs piece or box, fo that the brafs bar upon it may be between the two iron plates under the leather. The whole is faftened together by means of an iron piece, whofe lower part goes through the holes in the middle of the valve, and the two brafs rods, fo that its upper part getting between the two upper iron plates of the valve, preffes upon the leather, and makes it apply itfelf clofe to the upper brafs bar. This iron piece or rod ought to have two holes, one at the bottom, juft under the lower brafs rod, to hold it clofe by means of a pin or key; and another at its top, to faften it to another iron rod, which is continued quite to the top of the pump, in order to give motion to the bucket. The chief advantages of this kind of buckets are, that they give the freeft paffage to the water, having the leaft friction poffible, as they touch the barrel only at the upper end of the brafs box; and that the fand or gravel, which is commonly mixed with the water, cannot get between the bucket and the barrel, becaufe the leathern ring is higher than the brafs tube; befides, if by any accident the motion of one fide of the valve were hindered, the other would ferve till it were mended. See VALVE.

The conftruction of pumps is ufually explained by glafs models, in which the action both of the piftons and valves may be feen. In order to underftand the ftructure and operation of the common pump, let the model DCBL (*Plate* XIV. *Hydraulics*, *fig.* 4.) be placed upright in the veffel of water K, the water being deep enough to rife at leaft as high as from A to L. The valve *a* on the moveable bucket G, and the valve *b* on the fixed box H, (which box quite fills the bore of the pipe or barrel at H,) will each lie clofe, by its own weight, upon the hole in the bucket and box, until the engine begins to work. The valves are made of brafs, and covered underneath with leather for clofing the holes the more exactly: and the bucket G is raifed and depreffed alternately by the handle E and rod D *d*, the bucket being fuppofed at B before the working begins.

Take hold of the handle E, and thereby draw up the bucket from B to C, which will make room for the air in the pump all the way below the bucket to dilate itfelf, by which its fpring is weakened, and then its force is not equivalent to the weight or preffure of the outward air upon the water in the veffel K: and, therefore, at the firft ftroke, the outward air will prefs up the water through the notched foot A, into the lower pipe, about as far as *e*: this will condenfe the rarefied air in the pipe between *e* and C to the fame ftate it was in before; and then, as its fpring within the pipe is equal to the force or preffure of the outward air, the water will rife no higher by the firft ftroke; and the valve *b*, which was raifed a little by the dilatation of the air in the pipe, will fall, and ftop the hole in the box H; and the furface of the water will ftand at *e*. Then deprefs the pifton or bucket from C to B, and as the air in the part B cannot get back again through the valve *b*, it will (as the bucket defends) raife the valve *a*, and fo make its way through the upper part of the barrel *d* into the open air. But upon raifing the bucket G a fecond time, the air between it and the water in the lower pipe at *e* will be again left at liberty to fill a larger fpace; and fo its fpring being again weakened, the preffure of the outward air on the water in the veffel K will force more water up into the lower pipe from *e* to *f*; and when the bucket is at its greateft height C, the lower valve *b* will fall, and ftop the hole in the box H, as before. At the next ftroke of the bucket or pifton, the water will rife through the box H towards B, and then the valve *b*, which was raifed by it, will fall when the bucket G is at its greateft height. Upon depreffing the bucket again, the water cannot be pufhed back through the valve *b*, which keeps clofe upon the hole whilft the pifton defcends. And upon raifing the pifton again, the outward preffure of the air will force the water up through H, where it will raife the valve, and follow the bucket to C. Upon the next depreffion of the bucket G, it will go down into the water in the barrel B; and as the water cannot be driven back through the now clofe valve *b*, it will raife the valve *a* as the bucket defcends, and will be lifted up by the bucket when it is next raifed. And now, the whole fpace below the bucket being full, the water above it cannot fink when it is next depreffed; but upon its depreffion, the valve *a* will rife to let the bucket go down; and when it is quite down, the valve *a* will fall by its weight, and ftop the hole in the bucket. When the bucket is next raifed, all the water above it will be lifted up, and begin to run off by the pipe F. And thus, by raifing and depreffing the bucket alternately, there is ftill more water raifed by it; which getting above the pipe F, into the wide top I, will fupply the pipe, and make it run with a continued ftream.

So, at every time the bucket is raifed, the valve *b* rifes, and the valve *a* falls; and at every time the bucket is depreffed, the valve *b* falls, and *a* rifes.

As it is the preffure of the air or atmofphere which caufes the water to rife, and follow the pifton or bucket G as it is drawn up: and fince a column of water 32 feet high is of equal weight with as thick a column of the atmofphere,

from the earth to the very top of the air; therefore the perpendicular height of the piſton or bucket from the ſurface of the water in the well muſt always be leſs than 32 feet; otherwiſe the water will never get above the bucket. But when the height is leſs, the preſſure of the atmoſphere will be greater than the weight of the water in the pump, and will therefore raiſe it above the bucket: and when the water has once got above the bucket, it may be lifted by it to any height, if the rod D be made long enough, and a ſufficient degree of ſtrength be employed, to raiſe it with the weight of the water above the bucket, without ever lengthening the ſtroke.

The force required to work a pump, will be as the height to which the water is raiſed, and as the ſquare of the diameter of the pump-bore, in that part where the piſton works. So that, if two pumps be of equal heights, and one of them be twice as wide in the bore as the other, the wideſt will raiſe four times as much water as the narroweſt; and will therefore require four times as much ſtrength to work it.

The wideneſs or narrowneſs of the pump, in any other part beſides that in which the piſton works, does not make the pump either more or leſs difficult to work; except what difference may ariſe from the friction of the water in the bore, which is always greater in a narrow bore than in a wide one, becauſe of the great velocity of the water.

The pump-rod is never raiſed directly by ſuch a handle as E at the top, but by means of a lever, whoſe longer arm (at the end of which the power is applied) generally exceeds the length of the ſhorter arm five or ſix times; and, by that means, gives five or ſix times as much advantage to the power. Upon theſe principles, it will be eaſy to find the dimenſions of a pump that ſhall work with a given force, and draw water from any given depth.

The quantity of water raiſed by each ſtroke of the pump-handle, is juſt as much as fills that part of the bore in which the piſton works, be the ſize of the reſt of the bore above and below the piſton what it will. The preſſure of the atmoſphere will raiſe the water 32 feet in a pipe exhauſted of air; but it is adviſable never to have the piſton more than 20 or 24 feet above the level of the ſurface of the water in which the lower end of the pump is placed: and the power required to work the pump will be the ſame, whether the piſton goes down to be on a level with the ſurface of the well, or whether it works 30 feet above that ſurface; becauſe the weight of the column of air that the piſton lifts, is equal to the weight or preſſure of the column of water raiſed by the preſſure of the air to the piſton. And although the preſſure of the air on the ſurface of the well will not raiſe or force up the water in the pump-bore more than 32 feet, yet when the piſton goes down into the column ſo raiſed, the water gets above it, and may then be raiſed to any height whatever, above the piſton, according to the quantity of power applied to the handle of the pump for that purpoſe.

Pumps ought to be made ſo (ſays Mr. Ferguſon) as to work with equal eaſe in raiſing the water to any given height above the ſurface of the well. And this may be done by duly proportioning the diameter of the bore (in that part where the piſton works) to the height the water is to be raiſed, as that the column of water may be no heavier in a long pump than a ſhort one; or indeed equally heavy in all pumps from the ſhorteſt to the longeſt, on a ſuppoſition that the diameter of the bore is of the ſame ſize from top to bottom: and whatever the ſize of the bore be, above or below that part in which the piſton works, the power required to work the pump will be juſt the ſame as if the bore was of the ſame ſize throughout.

In order that a man of common ſtrength may raiſe water by pumps with the ſame eaſe, to any height not leſs than 10 feet, or more than 100 feet, above the ſurface of the well, Mr. Ferguſon has calculated the annexed table, in which the diameter of the bore is duly proportioned to the height; and in theſe calculations he ſuppoſes the pump handle to be a lever increaſing the power five times.

Height of the Pump, in Feet, above the Surface of the Well.	Diameter of the Bore.		Water diſcharged in a Minute, in Wine Meaſure.	
	Inches.	100 Parts of an Inch.	Gallons.	Pints.
10	6	·93	81	6
15	5	.66	54	4
20	4	·90	40	7
25	4	·38	32	6
30	4	.00	27	2
35	3	·70	23	3
40	3	·46	20	3
45	3	.27	18	1
50	3	.10	16	3
55	2	·95	14	7
60	2	.84	13	5
65	2	·72	12	4
70	2	.62	11	5
75	2	·53	10	7
80	2	·45	10	2
85	2	·38	9	5
90	2	·31	9	1
95	2	·25	8	5
100	2	·19	8	1

In the firſt column, look for the number of feet the water is to be raiſed; then, in the ſecond column you have the diameter of that part of the bore in which the piſton or bucket works; and in the third column, the quantity of water which a man of ordinary ſtrength can raiſe in a minute by the pump to the given height.

The quantity of water contained in a pipe of either of thoſe heights in the table, ſuppoſing the diameter of the bore to be the ſame from top to bottom of the pipe, is 4523.2 cubic inches, or 19.58 gallons in wine meaſure, as near as the hundredth part of an inch in the diameter of the bore can make it.

Mr. Ferguſon has calculated the following table, by which the quantity and weight of water in a cylindrical bore of any given diameter and perpendicular height may be very readily found.

Diameter of the cylindrical Bore one Inch.			
Feet high.	Quantity of Water in cubic Inches.	Weight of Water in Troy Ounces.	In Avoirdupois Ounces.
1	9·4247781	4·9712340	5·4541539
2	18.8495562	9·9424680	10.9083078
3	28.2743343	14·9137020	16.3624617
4	37·6991124	19·8849360	21.8166156
5	47·1238905	24·8561700	27.2707695
6	56·5486686	29·8274040	32·7249234
7	65·9734467	34·7986380	38·1790773
8	75·3982248	39·7698720	43·6332312
9	84·8230029	44·7411060	49·0873851

For tens of feet high, remove the decimal points one place towards the right hand; for hundreds of feet, two places; for thouſands, three places; and ſo on. Then multiply each ſum by the ſquare of the diameter of the given bore, and the products will be the anſwer.

Example.

Qu. *What is the quantity and weight of water in an upright pipe* 85 *feet high, and* 10 *inches in diameter of bore?* The ſquare of 10 is 100.

Feet high.	Cubic Inches.	Troy Ounces.	Avoirdupois Ounces
80	753.982248	397.698720	436.332312
5	47.1238905	24.8561700	27.2707695
85	801.1061385	422.5548900	463.6030815
Multiply by	100	100	100
Anſ.	80110.6138500	42255.4890000	46360.3081500

Which number (80110.61) of cubic inches being divided by 231, the number of cubic inches in a wine gallon, gives 342.6 for the number of gallons in the pipe: and 42255.489 troy ounces being divided by 12, gives 3521.29 for the weight of the water in troy pounds: and laſtly, 46360.3 avoirdupois ounces being divided by 16, gives 2897.5 for the weight in avoirdupois pounds.

The power required to work a pump, or any other hydraulic engine, muſt not only be equal to the weight of the whole column of water in the pump bore, but as much ſuperior to it as will overcome all the friction of the working parts of the engine.

Pump, *the Forcing*, raiſes water through the box H (*fig.* 5.) not in the ſame manner as the ſucking-pump does, when the plunger or piſton *g* is lifted up by the rod D *d*. But this plunger or forcer (ſee Forcer) has no hole through it, to let the water in the barrel B C get above it, when it is depreſſed to B; and the valve *b* (which roſe by the aſcent of the water through the box H when the plunger *g* was drawn up) falls down and ſtops the hole in H, the moment that the plunger is raiſed to its greateſt height. Therefore, as the water between the plunger *g* and box H can neither get through the plunger upon its deſcent, nor back again into the lower part of the pump L *e*, but has a free paſſage by the cavity around H into the pipe M M, which opens into the air-veſſel K K at P; the water is forced through the pipe M M by the deſcent of the plunger, and driven into the air-veſſel; and in running up through the pipe at P, it opens the valve *a*; which ſhuts at the moment the plunger begins to be raiſed, becauſe the action of the water againſt the under ſide of the valve then ceaſes.

The water being thus forced into the air-veſſel K K by repeated ſtrokes of the plunger, gets above the lower end of the pipe G H I, and then begins to condenſe the air in the veſſel K K. For as the pipe G H is fixed air-tight into the veſſel below F, and the air has no way to get out of the veſſel but through the mouth of the pipe at I, and cannot get out when the mouth I is covered with water, and is more and more condenſed as the water riſes upon the pipe, the air then begins to act forcibly by its ſpring againſt the ſurface of the water at H: and this action drives the water up through the pipe I H G F, from whence it ſpouts in a jet S to a great height; and is ſupplied by alternately raiſing and depreſſing of the plunger *g*, which conſtantly forces the water that it raiſes through the valve H, along the pipe M M, into the air-veſſel K K.

The higher the ſurface of the water H is raiſed in the air-veſſel, the leſs ſpace will the air be condenſed into, which before filled that veſſel; and therefore the force of its ſpring will be ſo much the ſtronger upon the water, and will drive it with the greater force through the pipe at F: and as the ſpring of the air continues whilſt the plunger *g* is riſing, the ſtream or jet S will be uniform, as long as the action of the plunger continues: and when the valve *b* opens, to let the water follow the plunger upward, the valve *a* ſhuts, to hinder the water, which is forced into the air-veſſel, from running back by the pipe M M into the barrel of the pump.

If there was no air-veſſel to this engine, the pipe G H I would be joined to the pipe M M N at P; and then the jet S would ſtop every time the plunger is raiſed, and run only when the plunger is depreſſed.

Mr. Newſham's water engine, for extinguiſhing fire (ſee Fire-*Engine*), conſiſts of two forcing-pumps, which alternately drive water into a cloſe veſſel of air; and by forcing the water into that veſſel, the air in it is thereby condenſed, and compreſſes the water ſo ſtrongly, that it ruſhes out with great impetuoſity and force through a pipe that comes down into it; and makes a continued uniform ſtream by the condenſation of the air upon its ſurface in the veſſel.

By means of forcing-pumps, water may be raiſed to any height above the level of a river or ſpring; and machines may be contrived to work theſe pumps, either by a running ſtream, a fall of water, by horſes, or by ſteam. See Water *Works*.

The rod of the bucket in a ſucking-pump is ſometimes made to work through a collar of oiled leathers and braſs plates connected with the barrel of the pump by ſcrews, and kept moiſt by water contained in a veſſel at the top: it prevents the water iſſuing from the top of the pump, and therefore, by a pipe, it will riſe to any height. This is called in the North, a *jack-head*. Deſaguliers's Exp. Phil. vol. ii. p. 152, &c. Ferguſon's Lectures, p. 73, &c. 4to.

Pump, *the Lifting*, differs from the ſucking-pump only in the diſpoſition of its valves, and the form of its piſton frame. This kind of pump is repreſented in *fig.* 6. A B is a barrel fixed in a frame I K L M, which is immoveable, with its lower part communicating with the water. G E Q H O is a frame with two ſtrong iron rods, moveable through holes in the upper and lower parts of the pumps I K and L M; in the bottom of this frame O Q H, is fixed an inverted piſton B D, with its bucket and valve upon the top at D. Upon the top of the barrel there goes off a part F R, either fixed to the barrel, or moveable by a ball and ſocket; but in either caſe water and air-tight. In this part, at C, is fixed a valve opening upwards. It is evident, that when the piſton frame is thruſt down into the water, the piſton D deſcends, and the water below will ruſh up through the valve D, and get above the piſton; and that, when the frame is lifted up, the piſton will force the water through the valve C up into the ciſtern P, there to run off by the ſpout. The piſton of this pump plays below the ſurface of the water. Mr. Martin has deſcribed a mercurial pump, which works by quickſilver, invented by Mr. Hoſkins, and perfected by Deſaguliers; and another pump of the lifting ſort, invented by Meſſrs. Goſſet and De la Denille, and ſet up in the king of France's garden at Paris, the piſton

of which works without friction. Phil. Brit. vol. ii. p. 57, &c. ed. 3.

Pump, *Ctesebes's*, the first of all the kinds, acts both by suction and pulsion. Its structure and action are as follow: —A brass cylinder A B C D (*fig.* 7.), furnished with a valve in L, is placed in the water. 2. In this is fitted the embolus M K, made of green wood, which will not swell in the water, and adjusted to the aperture of the cylinder with a covering of leather, but without any valve. In H is fitted on another tube N H, with a valve that opens upwards in I.

Now, the embolus E K being raised, the water opens the valve in L, and rises into the cavity of the cylinder: and when the same embolus is again depressed, the valve I is opened, and the water driven up through the tube H N.

This is the pump used among the ancients, and that from which both the others are deduced. Sir S. Morland has endeavoured to increase its force by lessening the friction; which he has done to good effect, insomuch as to make it work without almost any friction at all.

Pumps *for draining Mines* are worked by horses, or water, but more than either by the steam-engine, which, had it produced no other advantage than the facilities it offers in mining, would have been of more real value than any philosophical discovery ever made. The pumps for this purpose are generally sucking-pumps of the common construction, made of cast-iron, except that they have an opening at the lower part of the barrel, to give access to the valve or bucket when they require repair or renewal of the leathers, and this is closed by a door or lid, fastened on with screws. The pump rod is suspended by chains from the arched end of a lever situated over the pit, and put in motion by the piston of the steam-engine acting at the opposite end, or by a crank turned from a horse-wheel or water-wheel. When the depth is considerable, the pit is divided into two or three lifts, and as many different pumps used; the lowest to raise the water from the bottom of the mine into a cistern at the first lift, in which the second pump stands, and raises the water to a second cistern, from which the third or upper pump raises it to the surface, or to the level or subterranean passage, at which it can run off to some lower land than that on which the engine is erected. The rods of the three pumps are brought into one by bolting them together at the top, and are suspended from the beam or lever, as before-mentioned. They are made of wood, the lengths being united together by iron joints; but even these in deep mines are of such great weight as to require a second beam or lever, placed on the opposite side of the pit to the engine, and having a balance weight at the outer end; because it would be too great a weight for any beam to bear, if a sufficient balance were put upon the opposite end of the same working beam that bears the strain of working the pumps: if they are of light wood, a considerable portion of their weight is taken off, by their being immersed in the water which the pumps contain.

A plan which is common in the mines of Cornwall, obviates the necessity of thus balancing the pump rods; it is by employing forcing-pumps instead of lift or suction-pumps. In these the engine is employed to lift the weight of the rods, and their descent is the power that raises the water in the pump, by pressing down the piston or forcer, and expelling the water from the barrel at the bottom through a valve into a pipe, which ascends the pit. The construction of the pump is varied from that in common use, though its principle is the same. Instead of the barrel being bored correctly withinside, and fitted with the leathered forcer, the forcer is made rather longer than the stroke of the pump, and being made true and smooth on the outside, it is fitted in a collar of leather at the top of the barrel of the pump. By this means, when the piston is raised up and down, it increases and diminishes the capacity of the barrel, which being provided with valves at the bottom and at the foot of the pipe, it will raise or force up the water, in the same manner as the force-pump before described.

The suction-pumps before mentioned, used in mining, are always made of cast-iron, in lengths of six or eight feet, screwed together at the flanches, forming a long tube, which is called the pile or pillar of pumps.

The working barrel of each lift of pumps, or that length of pipe in which the bucket moves, is usually fourteen to twenty feet above the bottom, and has at its upper end a wider part, and a cover, which, like that above-mentioned, takes off by screws to new leather, or to repair the bucket. The bottom length of mine-pumps is called the wind-bore, usually enlarged at two or three feet from the bottom, and diminishing thence to a point like that of an egg, which part is full of rows of holes three quarters or an inch in diameter. The upper row of these holes is plugged up with deal plugs, which the miners can open or stop as the water increases, or otherwise, and according to the going of the engine. When a pit or mine is first sinking, it becomes necessary to contrive the means of drawing the water completely from the bottom, that they may not have to stand in the water to work, which, besides its inconvenience, prevents them using gunpowder if the bottom is rocky. Sometimes, instead of the plugs of wood, the holes of the wind-bore are surrounded by a circular apron of strong leather, made fast and tight above to the pipe; which apron the miners can from time to time turn up or down like the cuff of a coat, so as to regulate the access of water, and prevent, as much as possible, the drawing of air by the pumps, as this deranges the motion of the engine. In sinking pits, the lower lift of pumps should stand in the deepest hole which has been made in the bottom of the pit, and for this purpose, when a new hole has been made, either by picking, or blasting, near to the pumps, they are levered towards, and let to sink into such new hole. In long lifts and heavy pumps, this lowest and moveable length of the pump is wholly or in part suspended by strong ropes attached to the great windlass, which is, in all such cases, provided near the shaft for drawing the pump rods, or the pumps themselves, in cases of need. As the shaft is deepened, new lengths of pump barrels are added at the top of the lower lift, generally about a yard at a time, and the pump rods are lengthened as the pump requires. This, which is the common mode of working in sinking pits, has many inconveniences: 1. As it is necessary for the pumps, whilst sinking, to keep the water very low in the pit, the engine frequently goes too fast, in consequence of the pump drawing up air, and carries up by the violence of the current small pieces of stone, coal, or other substances, and lodges them above the bucket upon the valves, which must considerably retard the working of the pump, and wear the leather. 2. When the engine is set to work, (after having been stopped whilst working upon air, and consequently a quantity of air remaining in the pump-barrel, with the small stones, &c. deposited on the valves of the bucket,) it often happens that the compressure of the air by the descent of the bucket, is not sufficient to overcome the weight of the bucket valves so loaded with rubbish, and the column of water in the stand-pipes: the pump is hereby prevented from

catching its water. The usual remedy for this is to draw the bucket out of the working barrel, until a quantity of water has escaped by its sides to displace the air: this evil often arises from the unnecessary magnitude of the space between the bucket and clack. 3. The pumps being suspended in the pit by capstan ropes for the purpose of being readily lowered as the pit is sunk, the stretching of the ropes, (especially when sinking in soft strata,) occasions much trouble, by suffering the pumps to rest on the bottom and choke; but the most serious evil is, that the miners, in shifting the pump from one place to another, that they may dig in all parts of the pit, throw them very far out of the perpendicular, thereby causing immense friction and wearing in all parts, besides endangering the whole apparatus, by breaking the bolts and stays, and straining the joints of the pipes.

Mr. William Brunton, of Butterly iron-works in Derbyshire, has presented to the Society of Arts an improved pump for mining, which obviates all the above difficulties. To avoid the pump drawing air, he has introduced a side pipe, connecting the parts of the working barrel which are above and below the bucket, which pipe has a stop-valve, that the miner can regulate with the greatest ease, so as to keep the engine to its full stroke, without drawing air, by letting down the water from the upper part of the barrel into the lower, so that it is working again in its own water. Instead of having the whole weight of the lower lift of pumps standing on the bottom, it is fixed in the pit by cross beams, and the miner has only to lift and move an additional pipe or wind-bore, which slides upon the lower length of the pump like a telescope, to lengthen down, and this additional wind-bore is besides crooked, and turned aside like a short crank, which, by the facility with which it turns round in the leathered collar above the nose of it, can easily be removed into every fresh hole which is made in the botton by the miners. The pumps are supported in the pit by beams placed across at proper distances, so as to suit the lengths of the pipes, or lengths of the pump, which are nine feet. Short pieces are laid across these, with half circular holes in them, which being put round the pump, just beneath the flanches, firmly sustain its weight, but may quickly be removed when it is required to lower the pumps in the pit; and as they are not fastened by any bolt, they do not prevent the pumps being drawn upwards, if it becomes necessary to take out the pumps when the pit is full of water. The pumps by these means remain stationary and the suction-pipe lengthens as the pit is sunk, until it is drawn out to its full extent; the whole column is then lowered to the next flanches, and another pipe is added to the top. The pumps being thus kept stationary till nine feet are sunk, the pipe at the top will of course deliver the water at the same level at all times, and instead of being obliged to lengthen the column every yard sunk, it will only be necessary every nine feet. *Fig.* 4. of *Plate* XV. *Hydraulics*, explains the construction of Mr. Brunton's pump, being a section through the centre of the working barrel and suction piece. A is the door which unscrews to get at the clack of the pump; B is the working barrel, with the bucket D working in it; E is the clack, also shewn enlarged in *figs.* 5 and 6; F is the suction-pipe, and G G a moveable lengthening piece: this slides over, and includes the other when the pump is first fixed; but as the pit is sunk, it slides down over the pipe F, to reach the bottom. The outside of the inner pipe, F, is turned truly cylindrical and smooth, and the inside of the outer pipe G, at the upper end, for about six inches down, is made to fit it. The junction is made perfect, by leathers being placed in the bottom of the cup *a a*, which holds water and wet clay over them, to keep them wet and pliable, and consequently air-tight. The lower extremity of the suction-pipe G terminates in a nose R, pierced with a number of small holes, that it may not take up dirt. This nose is not placed in a line with the pipe, but curved to one side of it, like a crank, so as to describe a circle when turned round. By this means the miners, by turning it round upon the pipe F, can always place the nose R in the deepest part of the pit; and when they dig or blast a deeper part, they turn the nose about into it, the sliding tube lengthening down to reach the bottom of the hole, as shewn in the figure. By this means there is never a necessity to set a shot for blasting, so near the pump-foot as to put it in any danger of being injured by the explosion, as is the case in the common pump, in which this danger can only be avoided by moving the pump-foot to one side of the pit, which necessarily throws the whole column of pumps out of the perpendicular.

The construction of the clack is explained by *figs.* 5 and 6, the former being a section, and the latter a plan. L L is a cast-iron ring, fitting into a conical seat in the bottom of the chamber of the pump, as shewn in *fig.* 4; it has two stems, *l*, *l*, rising from it, to support a second iron ring M M; just beneath this, a bar, *m*, extends across from one stem to another, and has two screws tapped through it; these press down a second cross-bar *n*, which holds the leather of the valves down upon the cross-bar of the ring L, and this makes it fast, forming the hinge on which the double valves open, without the necessity of making any holes through the leather, as is common: but the chief advantage is, that by this means the clack can be repaired, and a new leather put in, with far less loss of time than at present, an object of the greatest importance; for in many situations the water gathers so fast in the pit, that if the clack fails, and cannot be quickly repaired, the water rises above the clack door, so as to prevent any access to it, and there is no remedy in the common pump but drawing up the whole pile of pumps, which is a most tedious and expensive operation. In Mr. Brunton's pump, the clack can at any time be drawn out of it, by first drawing out the bucket, and letting down an iron prong Z, which has hooks on the outside of its two points: this, when dropped down, will fall into the ring M, and its prongs springing out will catch the under side, and hold it fast enough to draw it up. Another part of Mr. Brunton's improvement consists in the addition of a pipe H, (*fig.* 4.) which is cast at the same time with the barrel, and communicates with it at the top and bottom, just above the clack: at the upper end the pipe is covered by a flat sliding plate, which can be moved by a small rod *b*, passing through a collar of leather; the rod has a communication by a lever, so that the valve can be opened or shut by the men in the bottom of the pit. The object of this side pipe is to let down such a proportion of the water which the pump draws, as will prevent it drawing air, though, of course, the motion of the engine will be so adapted as not to require a great proportion of the water to be thus returned through the side pipe, yet it will not be possible to work the engine so correctly as not to draw some without this contrivance, and if it does, it draws up much dirt and pieces of stone into the pump, besides causing the engine to work very irregular, in consequence of partially losing its load every time the air enters the pump. Another use of the side pipe is to let down water into the chamber of the clack to fill it, when the engine is first set to work, after the pumps have been standing still, and the lower part of the barrel and chamber empty.

Figs. 7 and 8, of *Plate* XV. are a section and elevation of a three-barrelled force-pump, of a very good

conftruction, which was ufed by Mr. Smeaton in the numerous water-engines which he erected at London bridge, Stratford, and other places for the fupply of towns with water. It has the advantage of the valves being very accef-fible, and the water-way may be kept to the full fize of the barrel without contractions, which, as they occafion great refiftance to the motion of the water, are a wafte of power. It acts on the fame principle as the ordinary forcing-pump, only that three barrels are connected together, for the advantage of raifing a conftant ftream of water. A, A, are the barrels, which are bored out truly cylindrical. If the pump is fmall, the barrels are ufually made of brafs, but for larger work caft iron is ufed. From one fide, near the bottom of each, proceeds a curved pipe B, turning up, and ending with a flaunch, to fcrew to the under fide of the forcing chamber L. There is alfo, near the bottom, at the oppofite fide of the barrel, a projecting neck or fhort pipe, D, covered at the end by a door fcrewed on, that it may be removed to give accefs to the valve, *m*, in the bottom of the barrel. The barrels have projecting rings or flaunches, by which they are fcrewed down upon the fuction chamber H, which is common to all three barrels; it has a pipe from each of its ends terminating in a flaunch *h*, to fcrew on the pipes which bring water to the pump. The upper flaunch, or top of the fuction chamber H, has three holes in it, one under each barrel, and each is covered by a valve fhutting downwards, as is fhewn in the fection, *fig.* 7. Thefe valves are made of iron, to fhut down upon hinges like a door, and are covered with leather at the lower fide. Mr. Smeaton made his valves with the centre pin of the hinge removed backwards from the hole which the valve covers, and it is alfo raifed above the furface of the under fide of the valve, by which means the valve opens in fome degree on that fide where the hinge is, as well as on the other, and any obftruction getting into the valve, will be lefs liable to be detained, and will not have fuch a great leverage to break the hinge of the valve when the force of the water fhuts it down, as it would if the hinge was on a level, and clofe to the edge of the hole, becaufe the obftacle will not be fo near the centre. The hinge is faftened to the pump by a fcrew, *w*, paffing through the metal, and fcrewing into the hinge; this being withdrawn, and the door, D, opened, the valve is quite loofe, and may be taken out to renew the leather. To give facility to this, the doors, D, are made oval, as fhewn in *fig.* 8. Another fimilar valve, *n*, is fitted at the top of each of the pipes, B, to cover their apertures; they are all covered by a common forcing chamber, L, which is exactly fimilar to the fuction chamber, except that it has noffels, R, in the top over each valve, and covered with doors to give accefs to them. The conducting pipes are carried away from either end of the forcing chamber, flaunches being provided to unite them. Each barrel is fitted with a pifton or forcer M, which confifts of three metallic plates, fecured to the rod: the middle plate is turned true, and fitted as accurately as poffible to the barrel; the upper and lower plates are fomewhat fmaller. Two round pieces of leather, larger than the barrel, are placed above and below the middle plate, being held faft between it and the upper and lower plates. When forced into the barrels, thefe leathers turn up and down round the upper and lower plates, forming two cups of leather, which accurately fit the barrel, and will not permit any fluid to pafs by them. The parts of the pump are faftened together by fcrews and nuts, as will be underftood by infpection of the figures. The whole pump is fupported on two ground-cills, and by means of two iron flaunches of the function chamber, H, the whole pump is bolted down upon the ground-cills. The action of this pump is fimply this; when the pifton or forcer of one barrel is raifed, it caufes a vacuum in it, and the preffure of the atmofphere forces the water up the fuction pipe H, (if not more than 30 or 33 feet,) opens the valve, *m*, in the bottom of the barrel, and fills it with water: on the defcent of the forcer the lower valve fhuts, and the forcing valve, *n*, opens by the water the barrel contained being driven through it into the forcing chamber, L, and thence to any place whither the forcing-pipe is carried. On the re-afcent of the forcer, the lower valve, *m*, opens, and the fhutting of the forcing valve, *n*, prevents the water returning into the barrel. The three forcers work up and down alternately, fo that while one barrel is fending water up the force pipe, the others are lifting it up the fuction pipe, and the third continues the action in the interval, when the change of motion takes place between the two. In this manner, the pump will raife a very conftant ftream of water, if the forcers are worked in a proper manner, which is beft done by means of cranks, placed at fuch an angle to each other, upon the fame axis, that they will act in due fucceffion.

PUMPS *for Ships*. – Among the perils of a fea-faring life, a leaking fhip may be reckoned the moft dreadful and fatal of all others: here not only one man, or a few men, perifh, but every living creature on board. When a fhip ftrikes againft a rock, and is wrecked, fome lives may be faved by floating planks and rigging; if the magazine takes fire, death comes inftantaneoufly, and kills, perhaps, in the moft gentle manner; but in the defperate cafe of a leak, how flowly does the awful monarch advance, attended by all the terrors of anxious fufpence.

In fuch a melancholy fituation, all their hopes and expectations for help and fafety muft be placed in the pumps, and this confideration renders thofe machines of vaft eftimation and confequence; it highly imports every commander of a fhip (to whom the lives of his men are committed) to take the utmoft care that his fhip be fupplied with fuch pumps as will beft provide againft, and ward off, thefe impending dangers. By any negligence in this refpect, he may become guilty of deftroying his own life, the lives of his men, and of the ruin and mifery of many families; it therefore becomes his duty to be furnifhed with the beft pump that can be procured for evacuating the hold from the water that may, at any time, get in, with the leaft force, and in the fhorteft time.

At different times, almoft every defcription of pump has been employed in fhip fervice; but cuftom has at length decided in favour of the chain-pump, although, from the friction naturally attending its conftruction, it takes fomewhat more power to raife a certain quantity of water than fome other kind of pump when well made. Yet on the whole, from being fo little liable to choke up or be deranged by violent ufe, it has gained the preference with the feamen. Conftant attempts have been made to produce a pump that would raife a greater quantity of water than the chain-pump with the fame power, and ftill to preferve the other advantages of that machine.

Thefe inventions have been offered to the public one after another, with pompous recommendations by their refpective projectors, who have never failed to report their effects as confiderably fuperior to that of other pumps with which they have been tried. It is, however, much to be regretted, that in thefe forts of trials there is not always a fcrupulous attention to what may be called mechanical juftice. The artift who wifhes to introduce a new piece of mechanifm, has generally fufficient addrefs to compare its effects with one of the former machines which is crazy, or out of repair: a report of this kind, indeed, favours ftrongly

of the evidence of a falſe witneſs; but this fineſſe is not always diſcovered. The perſons appointed to ſuperintend the comparative effect of the different pumps, have not always a competent knowledge of hydraulics to detect theſe artifices, or to remark, with preciſion, the defects and advantages of thoſe machines, as oppoſed to each other. Thus, the ſeveral inventions propoſed to ſupplant the chain-pumps which are now generally uſed in the Britiſh navy, have hitherto proved ineffectual, and are no longer remembered.

In many inſtances, for want of a proper knowledge of mechanics and hydraulics, theſe inventions have proceeded upon a miſtaken principle, ſuppoſing it poſſible to make ſome contrivance or other, by which a pump ſhould raiſe more water with a certain power than has ever been done before. This is a miſtaken idea, for pumps, in point of the quantity of water they will raiſe, have long ago been brought to as great a degree of perfection as it is perhaps poſſible; and to raiſe a greater weight of water than the power applied is equal to, is an impoſſibility, as no power or effort can really be increaſed by any kind of machinery, it can only be modified; and what is gained in the magnitude of the effect the machine produces, is loſt in the time expended to accompliſh it: in truth, rather more is loſt, becauſe of the friction of the machine, and the power expended in working its parts; we ſhould, therefore, aſcertain the quantity of water that can be raiſed in a given time by the force of one or more men, without deductions for friction; and when a ſhip's, or other pump is to be conſidered, if its produce comes near to this ſtandard, we ſhould be ſatisfied as to its performance, and look for improvements in the conveniences of its conſtruction.

Deſaguliers, in the ſecond volume of his Experimental Philoſophy, has taken much pains to find out an average of the quantity of water which can be raiſed in a given time by any number of men; and this will ſerve to guide us in theſe purſuits, and to enable us to value the pretenſions of projectors in the art of raiſing water. He found, that the mean ſtrength of a man, when applied to the beſt kind of pump that had been in his time made, amounts to no more than the raiſing of one hogſhead of water in a minute, to the height of ten feet. Mr. Smeaton ſays, he made a variety of machines, and many obſervations of this kind, but never found the value of men's ſtrength at a medium quite equal to what is ſet down by Deſaguliers, unleſs they are ſuppoſed to work in haſte or diſtreſs for a few minutes.

The improvements which are deſirable in pumps for a ſhip's uſe, are, 1ſt, that as little power as poſſible ſhould be loſt in friction and reſiſtance of the water paſſing through the valves and pipes; 2dly, that no water be loſt by leakage, and that the pump be not liable to choke up by chips or other extraneous matters getting into the pump; 3dly, it ſhould not be obliged to raiſe its water to a greater height than is neceſſary for it to run off, namely, to the load-water line of a ſhip; laſtly, that it ſhould be ſo adapted, that the united efforts of a great number of men can be applied, without any of them working to a diſadvantage. The pumps which are at preſent in uſe in the navy are of two kinds, the chain-pump, and the hand-pump; the chief dependence of pumping the ſhip, in emergency, being placed upon the former, the latter being uſed in ordinary occaſions, to clear the hold from that trifling leakage which would injure the cargo, though it puts the ſhip in no danger.

Engliſh ſhips of war carry four chain-pumps and three hand-pumps, all being fixed in the ſame well, which alſo includes the main-maſt. (See *Plates* IV. and VI. of *Naval Architecture*.) One of the hand-pumps is called the waſh-deck pump, being uſed to raiſe water from a ciſtern in the hold to the upper deck, for waſhing the ſhip; but in emergency, it aſſiſts to pump the ſhip. The chain-pump (*Plate* XIV. *fig.* 8.) is no other than a long chain, A, with a ſufficient number of piſtons, *a*, called buckets or ſaucers, fixed upon it at proper diſtances: it paſſes downwards through a wooden tube, B, and returns upwards, in the ſame manner, on the other ſide, D; the ends being united together. The chain is extended over two wheels, E and F, called ſprocket wheels: one is placed over the tubes, B and D, of the pump, and the other at the bottom, in the ſpace between the two tubes through which the chain aſcends and deſcends. By turning the upper wheel, E, the chain of buckets is put in motion; and the lower part of the wooden tube, in which the chain aſcends, is lined with a braſs barrel, in which the ſaucers are fitted. As they are continually aſcending in this tube, they raiſe a conſtant ſtream of water, which runs off from the top of the aſcending trunk, and is carried by a trunk through the ſhip's ſide into the ſea. The pump is worked by a crank, or winch, G, fixed on the axis of the upper wheel, whereon ſeveral men may be employed at once; and thus it diſcharges, in a limited time, a much greater quantity of water than the common pump, and that with leſs inconvenience to the labourers.

The chain-pump now in uſe in the navy is of a very improved conſtruction, compared with original chain-pumps. It was introduced by Mr. Cole, under the direction of captain Bentinck. The chain of this machine is ſimple, and not much expoſed to damage. It is exactly ſimilar to that of the fire-engine, and appears to have been firſt applied to the pump by Mr. Mylne, to exhauſt the water from the caiſſons at Blackfriars bridge. It has thence been transferred to the marine by captain Bentinck, after having received ſome material additions to anſwer that ſervice. The links of the chain (*fig.* 9.) are each formed of two long plates of iron, *e*, *e*, with a hole at each end, and fixed together by two bolts, ſerving as pins for the joints. The buckets or ſaucers fixed upon it are two circular plates of braſs, *g*, with a piece of leather between them. The ſprocket wheels for the chain are formed in the ſame manner as the trundles uſed in mills, by two iron wheels fixed at eight inches diſtance upon the axle, and united by ſeveral round iron bolts, forming a reſt for the chain; and its links have hooks, *b*, which are taken by theſe bolts; and thus the chain is ſecured upon the wheel, to prevent it from jerking back, when charged with a column of water.

This pump was a great improvement upon the old chain-pumps uſed [illegible] ſhips befo[illegible] which the chain was of too complicated a fabric, and the ſprocket wheels uſed to work it were deficient, in wanting ſome contrivance to prevent the chain from ſliding or jerking back upon the ſurface of the wheel, which frequently happened when the buckets were charged with a conſiderable weight of water, or when the pumps were violently worked. The links were too ſhort, and the awkward manner in which they were connected expoſed them to a great friction in paſſing round the wheels: hence they were ſometimes apt to break, or burſt aſunder, in very dangerous ſituations, when it was extremely difficult or impracticable to repair the chain. Mr Cole's pump is ſo conſtructed, that the chain may be eaſily taken up and repaired, when broken, or choaked with ballaſt; and it diſcharges a much greater quantity of water with an inferior number of men, as appears from a trial of this machine with the old chain-pump aboard the Seaford frigate; where it was found that its effects, when compared with the latter, were as follows: the new pump with four

men raised one ton of water in $43\frac{1}{2}$ seconds, while the old pump required seven men to raise the same quantity of water in 76 seconds. In this experiment, the chain of the new pump was purposely broken, and dropped into the well, and afterwards taken up and repaired, and set to work again in two minutes and a half: then the lower wheel of the pump was taken up, to shew how readily it might be cleared and refitted for action, after being choaked with sand or gravel, which could be performed in four or five minutes. These are advantages which, with a seaman, have a superior consideration to that of increasing the quantity of water which the machine will raise, unless it was in a considerable degree; and indeed the very best pumps will not raise a much greater proportion with the same power. The only alteration which has been made on Mr. Cole's pump, since its first introduction near 30 years ago, is that they now omit the lower sprocket wheel altogether, the ascending and descending pipes being so united by a curved metal tube, that the chain passes better than if a wheel was used. The cranks are made to take off, and apply when wanted, that they may not be in the way: they are long enough for 30 men to work at once. Of late it has been proposed to add fly-wheels to them: this would be attended with but slight advantage, and several inconveniences, from occupying that room where the men should stand to work, it being an object to employ as many as possible; but if they are crowded, they only incommode each other, instead of assisting.

Hand-pumps for ships, are those which act with a barrel and bucket, worked by a lever or brake. Those in common use are sucking-pumps, made in the rudest manner, with a wooden bucket and valves; but several improved constructions have been proposed, and are now adopted in the navy. Mr. Cole made great numbers of hand-pumps, which had brass chambers, or barrels, fitted into the wood where the bucket worked. The valves were made of brass, and fitted into a conical seat, and a door was provided in the lower part of the pump, to give access to the lower valve when requisite; it was closed by a hoop surrounding the pump, and wedged tight. The brake, or lever of the pump, had a cross handle at the end, of sufficient length to allow several men to work together, and on occasion other men could apply their strength, by standing on the deck below, and having a rope descending through the upper deck from the end of the brake.

Mr. Smeaton, in 1765, invented a hand-pump for the sea service, in which, besides the advantage that he expected to obtain from better mechanism and proportion of the parts, he had the following objects in view. The common ship's pump, in general, delivers its water upon the main deck, which, according to the size and construction of the ship, is four, five, or six feet above the surface of the sea, or load-water line, at the same time that this line is not above from 14 to 18 feet above the ship's bottom; it therefore appears that the ordinary pumps lift the water from $\frac{1}{3}$d to $\frac{1}{4}$th higher than the level at which the water might be delivered, and thereby require $\frac{1}{3}$d or $\frac{1}{4}$th more power to do the same work, or with the same power they do less work than they might do by $\frac{1}{3}$d or $\frac{1}{4}$th, in case the water was delivered at or just above the water line. For this purpose he used wooden trunks or pipes, proceeding horizontally from the upright trunk of the pump, to carry off the water through the ship's side, being fitted at the other ends into boxes, or short wooden tubes, let in through the ship's side, and caulked just above the load-water line. These side pipes were closely jointed with the boxes in the ship's side at one end, and at the other end into strong planks, which were bolted against the sides of the pump, in order that the side pipes might be got out and in without disturbing the pump, which was a sucking-pump, with its bucket worked by a lever or brake, upon the deck over the pump. From the top of the pump a stand pipe was carried up to the main deck, or as high as was thought necessary, to prevent the water reverting and running back into the ship over the top of the pump, when the sea rose above the orifices of the side pipe, or when, from the ship being in distress, they were under her load-water line. By this, even when both boxes and pipes were wholly under water, it would no ways interrupt the action of the pump, for whenever the water in the stand pipe rose above the level of the water without, the pressure of the column in the stand pipe would cause it to make its way through the side pipes, so that in this case no level was lost, and though the pump was at rest no water could revert down the pump, because there were the valves of both bucket and fixed box or clack which prevented it. The working barrel was of brass, and very truly bored, the bucket and fixed box being of the same construction as those used in the steam-engines, and the pump rod was made of greater bulk than was necessary, merely for strength, but by way of weight, that when the brake was lifted up, the pump rod should readily descend by its own weight. The brake of the pump had a branch fixed on, rather obliquely at each side, so as to form three handles, for four men to work at once; they stood one on each side the middle stem of the brake, and one on the outside of each of the branches, and every quarter of an hour they could relieve themselves by changing hands, which was done by changing places. They were intended to make no more than 25 strokes *per* minute, moving the pump rod $17\frac{1}{2}$ inches, up and down, at each stroke, the barrel being a nine-inch bore; this was much better than making shorter strokes and quicker, as they usually do. Their hands moved up and down about four feet six inches, and by working with this stroke at a moderate rate, so as to hold it an hour, four men would in that time deliver 20 tons at a height of 22 feet. This was upon a supposition of raising the water to the usual height, but when by the application of the maxim before described, this perpendicular was shortened to 16 or 17 feet, then nearly the same delivery could be made by three men, or proportionably more by four men, that is, as 17 : 22 :: 20 : 26 tons at 17 feet. The foot of the pump was let through the ship's inner planking or ceiling, betwixt two of the floor timbers, and did not touch the bottom or outside planking, within $2\frac{1}{2}$ inches, the lower end being rounded withinside like a trumpet mouth, it being a bad plan to have the pump standing upon its lower extremity, with holes bored to let in the water, as it is thus very liable to be choaked by dirt. A plank of the ceiling was made to lift up near the pump's foot, that a man could occasionally get in his arm, to clear away any chips, sand, dirt, or other matter, that should happen to be drawn thither.

Mr. Noble has furnished a great number of hand-pumps for the navy, which have two buckets, working one below the other in the same barrel: they rise and fall alternately, so as to produce a constant stream, like the chain-pump. This is effected by causing the rod for the lower of the two buckets to pass down through the upper bucket in a collar of leathers: the rods of the two buckets are united to the brake or lever, upon opposite sides of its centre or fulcrum, so that the descent of one produces the elevation of the other; thus one is always raising a stream of water, whilst the other is descending for a fresh supply. Such a pump requires no lower valve, unless by way of precaution, in case either bucket should fail, in which case it would become a single pump. The idea is ingenious; but the

complication of the ſtuffing-box in the upper bucket prevents them being readily taken out, if the pump choaks up, as all ſhips' pumps are liable to do from chips or looſe ballaſt; and hence it has never been in favour with the ſeamen, although it acts very well when in order.

The ingenious Benjamin Martin invented a ſhip's pump with two barrels drawing from one ſuction-pump, ſo as to raiſe a conſtant ſtream. This has ſo much merit, that we have given a ſection of it in *Plate* XV. *fig.* 9. Here A is the ſuction pipe, conducting the water from the ſhip's hold up to the pump, where it is enlarged, to communicate with both barrels D, D, through the valves C, C, in the bottom; E, E, are the piſtons of the barrels, with double valves in them; they are not, like other piſtons, fitted to ſlide in the barrels, but are ſimply braſs rings, in which the valves are fitted, and being ſmaller than the barrels, have large circular pieces of leather fixed on them, the outſide edges of which are attached to the inſides of the pump barrels; hence when the piſtons are moved up and down, the leather folds ſufficiently to admit the motion, as is ſhewn in the figure; but being cloſe all round, theſe piſtons can have no leakage or friction, and only a ſmall reſiſtance from the ſtiffneſs of the leather. To faſten the edges of the leather piſton to the barrels, they are made in two lengths, an upper and a lower, and the leather is introduced in the joint between them, being held faſt, and the pump kept together by bars, I, I, fixed over the barrels, and bolts to preſs the upper length of the barrels down upon the lower. Both the barrels are included within a box or ciſtern, B B, fixed upon the ſhip's deck, with trunks L, L, which carry off the water as it runs over the tops of the barrels into the ciſtern. The pump is worked by the piſton-rods, H, H, being united by chains to a wheel K, the axle of which is ſupported by ſtandards from the ſides of the ciſtern B B, and is put in motion by the double lever M, at the ends of which croſs handles are fixed for ſeveral men to work at once. Mr. Martin's pump acts extremely well; the conſtant ſtream raiſed by the alternate action of the two barrels upon one pipe produces an advantage that was ſhewn by experiment, for the water not only riſes while the piſton riſes, but continues to do ſo even after the piſton begins to deſcend; and therefore the pump was found to deliver more water than was expected from calculation of the contents of the barrel and the number of ſtrokes made.

To account for this, it muſt be conſidered that as this pump has both its large piſtons working (alternately aſcending and deſcending), at the ſame time there muſt be produced a conſtant riſing column of water in the pipe, whoſe velocity through a bore of five inches, to ſupply the barrels of twelve inches diameter each, muſt be ſo great, that it cannot be checked or ſtopped at once, or upon the firſt deſcent of the piſton; and therefore a ſurplus of water is produced. Notwithſtanding theſe advantages of Mr. Martin's pump, it has objections which are ſerious obſtacles to its uſe on board ſhips, though in other ſituations it is a good machine: theſe are the ſhortneſs of its ſtroke, which renders it very fatiguing for men to work for a long time; but another more ſerious objection is, that the leathers would, in general, remain dry, and thus become liable to harden and grow ſtiff, ſo as to break into holes when uſed at firſt, before they become ſoaked, and to fill the ciſtern firſt with water would be very troubleſome.

Mr. Robert Clarke, of Sunderland, has propoſed an improvement in the mode of applying men's force to pumping, which is worthy the conſideration of ſeamen. It is to change the poſture of ſtanding to ſitting, and making the action the ſame as that of rowing, which, beſides that it is by philoſophers conſidered as the moſt efficacious application of a man's force, is to ſeamen moſt particularly ſo from their habitual practice of it. He objects to the ordinary action of pumping with a brake, as the poſture is weak, and requires much force to preſerve it. It oppreſſes the man by overſtretching his loins on one ſide, and incommodes reſpiration, by the flexure of the body on the other ſide. Too much motion of the ſhoulder-joint is required, as the muſcles which act on the arm-bone at this joint are diſproportionate to the effort they muſt make, when the arm vibrates on the ſhoulder-joint as a centre, for the force to be communicated by the hand. Beſides this, the arms themſelves are at one inſtant enfeebled, by being thrown above the head, and requiring a pull, and the next inſtant require a puſhing effort, which changes of direction in the exertion and ſuſtaining force, are too continual and rapid for long continuance; in ſtanding, the body is a continued dead weight upon the legs.

The action of rowing is powerful to a ſurpriſing degree, and ſo well adapted to a man's eaſe, that he can continue it a greater length of time without fatigue, than any other mode of exertion; for though the motion is large, it is made up of eaſy motions in ſeveral joints; the velocity and reſiſtance of which ſuit the muſcles employed. Very little ſuſtaining force is required, for the body is ſupported, and returns unloaded to its charge: the breathing is free. The manner of carrying this into effect is very ſimple, the lever or brake being bent at right angles at a centre pin, ſo that it hangs ſtraight down when it is at reſt, inſtead of being horizontal; then to the lower extremity a rod is jointed, which is carried rather in an inclined direction upwards to the ſeamen, who is ſeated before the pump with a reſt for his feet. The rod has a croſs handle, to hold by both hands, and in ſome caſes it may be made long enough for two men to ſit ſide by ſide upon the ſame ſeat; and by drawing and puſhing it, in the ſame manner as rowing, the perpendicular lever is cauſed to vibrate, and the horizontal arm, or bended part, which ſuſpends the pump ſpear, partakes of the motion ſufficiently for pumping.

The lateſt improvements in hand-pumps, are by Capt. Jekyl, R. N. This gentleman has invented an addition to the pump of an air-veſſel, and ſtuffing-box for the rod to paſs through, by which it will raiſe the water to a greater height than the head of the pump, and a hoſe being attached to the pump ſpout, by very ſimple means, the water is conveyed to any deſired part of the ſhip, and thrown in a jet through a noſe pipe with great force, to extinguiſh fire, if ſuch a calamity ſhould befall a ſhip, and thus the pump is rendered of twofold ſervice. The idea of converting the pump to a fire-engine is not new, having been attempted in many different ways by forcing-pumps, but theſe having pipes proceeding from the lower part of the barrels and valves, which are not very acceſſible, are always liable to choke up by obſtructions, and have not ſucceeded in general uſe. The air-veſſel has always been in the way, if made of a ſufficient ſize, to anſwer the purpoſe of equaliſing the ſtream. Capt. Jekyll has obviated theſe objections, and, without altering the material parts of the hand-pump, has rendered it as complete a fire-engine as can be wiſhed. This is explained by *fig.* 1. *Plate* XV. which is a ſection of the pump through its whole length. A B C is the iron brake or lever to work it; it is branched at the extreme end, and has a wooden pole, C, fixed in it, for ſeveral men to hold at once; D is the iron ſtanchion or fulcrum of the brake; it is fixed to the pump head by means of ſtrong iron hoops at E E and F F, which at the ſame time ſtrengthen the work of the pump. The centre pin is to be at a height of two

feet fix inches above the fhip's deck. H are the flings of the pump, united by a forelock or pin to the end of the brake, and fufpending the pump fpear I, by means of the joint-piece *g*. I K is the pump fpear, made of copper in the upper part, I, and the lower length, K, of iron; the latter has the bucket, M, attached to it. The valve of the bucket is made in a very fimple and effective manner, the valve being merely a round plate of brafs, with a hole through the centre, to receive the rod, upon which it rifes and falls, and covers the aperture in the bucket. The bucket is a ring of brafs, with a crofs-bar to fix the rod in; it is made in two thickneffes, one above the other, and a cup of leather is held in between them, projecting all round the upper part of the bucket, and turning up, to make a tight fitting in the barrel. The two rings of the bucket are held together by the pifton-rod paffing through both, and a crofs-wedge beneath. L is the brafs chamber in which the bucket works; it is well fitted into the wood of the pump-tree, fo that the water cannot leak by it, and is bored fmooth withinfide. N is the lower box, fitted into the lower part of the pump-tree, beneath the chamber; it has a groove round it, into which oakum is placed, and when it is put down, makes a tight joint: its valve is of the fame conftruction as that of the bucket, with the addition of a ring or eye on the top of the pin, on which the valve rifes and falls. By this eye the box can be drawn up when it needs repair, by firft drawing up the bucket of the pump, and putting an iron hook down into this eye. O O P is the air-veffel; this is a cylinder of fheet copper, foldered to a cover of brafs; within the centre of it is a tube, likewife foldered to the cover, through which the copper pump fpear paffes, and is fitted round at top with a collar of leather and ftuffing. To prevent the efcape of the water, it is packed with hemp, and two rings of leather. R fhews the place of two iron bars, fitted through the head of the pump, and confining the cover, O O, of the air-veffel; they are faftened by the wedges *d*: it is by thefe only that the air-veffel is held down: a circle of leather is firft put round the air-veffel, juft beneath its lid, and this being preffed upon the recefs in the wood, makes the joint tight. T is the pump nozzle, which delivers the water. When it is ufed as a fire-engine, a hofe is fixed on by its link-joints, and keys or wedges: the nozzle is fixed to the pump by four fcrew-bolts going through the thicknefs of the pump, and it is fixed in fuch a direction as will moft conveniently lead to a receiver, *fig.* 2, which unites the hofes from all three of the fhip's pumps.

Fig. 3. is the link-joint of the hofe, T reprefenting the pump-fpout made of caft iron, and fcrewed to the pump-tree; *e e* is the collar or focket, made of brafs, with the hofe X bound upon it: this has two trunnions, on which a link, *f*, is fitted, one on each fide; thefe links pafs through grooves, in the caft-iron piece T, and a key *g*, put down through the link behind it, draws the joint tight, without any fcrewing or further trouble. The focket, *e e*, is fitted into the nozzle, and has a leather ring to make it tight. The outfide of the pump is to be hooped at every three feet, to prevent it from burfting by the preffure of the water. The difpofition of the three hand-pumps in a fhip's well, renders their connection with a common receiver very convenient to bring all the water into one ftream, which will then be very powerful, and more capable of extinguifhing a fire than any moveable engine. Two hand-pumps are always placed on the ftarboard fide of the main-maft, in the well, and one of them being the ciftern pump ufed for wafhing decks, its foot ftands in a fmall ciftern fixed upon the ftep of the main-maft, and fupplied with water by a pipe through the fhip's fide, with a cock to admit it at pleafure; there is one pump on the larboard fide of the maft, three feparate hofes being united with each of the pumps by a link-joint, like *fig.* 3, at one end, and with three necks, *k*, *k*, *k*, of a receiver, *fig.* 2, by fimilar joints at the other, brings all the water into one, and a hofe being joined by a link-joint, *l*, to the oppofite end of the receiver, conveys the whole water to any part of the fhip. The receiver has the three nozzles, *k*, *k*, *k*, at one end made in a divergent direction, agreeable to the directions in which the hofes came from the three different pumps, and a valve is placed withinfide, before each nofe, to open inwards, in order that the receiver may be ufed for one or two pumps, whilft the others are repairing, or getting ready, or that if any of the hofes burft, the water may not efcape from the receiver at that nozzle. There are two handles fixed to the receiver, to lift and carry it, as it is to be moveable, and when in ufe, is propofed to be laid on the grating of the main hatchway, as the moft central fituation, from which the hofe may be carried in any direction. Z is a branch pipe, or jet, fcrewed at the end of the great hofe, X; and it alfo unfcrews at the extreme end, to fit on jets of different bores, in the fame manner as all other fire-engines. In working, the preffure of the water condenfes the air contained in the receiver, O O P, into a fmall fpace, and its reaction to refume its former bulk equalizes the efflux of water from the nozzle of the pump.

In fome experiments which we have witneffed upon this pump, it performed as well as could be defired, a fingle pump forming a very effective engine; but when the three were combined, it was fuperior in force to any we have ever feen, and would throw a ftream, of an inch in diameter, over the main-top-maft head of a 74-gun fhip. Befides, the length of the handle, C, admitting feveral men to work at once, an acceffion of force is gained by a rope, *n*, made faft to the brake A B, and conducted through a fingle block, hooked to the deck at *m*, and thence along the fhip's deck. At this any number of men may be applied very advantageoufly, to produce the ftroke, leaving thofe at the handle only to return it by lifting the handle. If the fhip proves leaky, and the ftuffing-box is thought to be an obftruction to the working of the pump, the air-veffel may be taken out, by drawing the wedges *d*, and taking out the bars R, which confine it; then after taking out the key which connects the joint-piece, *g*, with the copper rod, alfo removing the brake, lift out the air-veffel by the two fcrews of the ftuffing-box, and fix on the joint piece again, but fix the guide-eye, H, in the loweft pair of holes, fo that it will receive the top of the copper rod, and prevent the pump fpear having any play in the flings. In this ftate it acts as a common hand-pump, but the air-veffel can be reftored to its place, and be ready for work in two minutes. To prevent any of the work being neglected from careleffnefs, the inventor propofes that one of the pumps fhall be always ufed to wafh the fhip by the hofe and jet in the morning, which it would do much more effectively than by the prefent mode of raifing the water into buckets; and the force with which the jet of water is thrown would very completely wafh into every recefs of the gun carriages, and other places, where a brufh cannot reach; while, by this conftant exercife the pumps would always be ready at a moment's notice on an alarm of fire.

Pump, *Air*, in *Pneumatics*, is a machine, by means of which the air is emptied out of veffels, and a fort of vacuum produced in them. For the invention, ftructure, and ufe of this pump, fee Air-*pump*; and for Smeaton's improved gage, fee Gage.

Pumps, *Bare*, are fmall ones made of cane, or a piece of wood bored through, ufed in lieu of cocks, &c. to pump beer or water out of the cafks.

PUMP-*Ciſterns*, ciſterns of wood fixed over the heads of

Pyrites

PYRITES, *Sulfure metallique*, in *Mineralogy* and *Chemistry*, a name given to certain ores which contain a large quantity of ſulphur, and have a metallic luſtre. The Greek word πυρίτης, formed of πυρ, *fire*, denotes fire-ſtone; a denomination given to this ſubſtance on account of its inflammability. For the mineralogical characters of copper pyrites,

and iron pyrites, see COPPER *Ore*, and IRON *Ore*.

Besides these there are arsenical pyrites, auriferous pyrites, and tin pyrites. Combinations of sulphur with the metals are called by chemists sulphurets; and the different kinds of pyrites are properly metallic sulphurets. Sulphur has a great affinity for iron, and in combination with this metal, under the form of pyrites, exists in extensive beds in primary mountains, or is disseminated through the secondary rocks and strata, in veins and masses, or variously crystallized: it occurs also in beds of coal and bituminous clay. Iron pyrites may be considered, after the earths, as one of the most abundant substances in the mineral kingdom, forming a constituent part of the globe, and by its decomposition giving rise to many important subterranean phenomena.

The proportions of iron and sulphur in the different subspecies of iron pyrites enumerated by mineralogists are,

52 to 54 Sulphur
48 to 56 Iron.

Magnetic pyrites differs from common pyrites: its constituent parts, according to Mr. Hatchett, are,

36.50 Sulphur
63.50 Iron.

By the application of heat common pyrites becomes susceptible of attraction by the magnet; the excess of sulphur being expelled. Iron pyrites is not worked as an ore of iron, but is principally valued for the green vitriol or sulphate of iron, which it affords when exposed to air and moisture. Sulphur may also be obtained from pyrites when heated with charcoal.

The decomposition of pyrites is effected spontaneously by the absorption of oxygen from water and the atmosphere, which converts the sulphur into sulphuric acid, and the iron into an oxyd. These substances unite during the process, and form the sulphate of iron, or green vitriol.

Some kinds of pyrites are rapidly decomposed, others require to have part of the sulphur expelled by heat. The pyrites, or pyritous substance intended to form vitriol, is collected in extensive heaps, spreading the surface as much as can be conveniently done. The ground on which these heaps are spread should be impervious to water, and inclined, in order that the saline matter which effloresces may be washed off, and conveyed into reservoirs to crystallize. As the decomposition proceeds the mass becomes heated, and is occasionally moistened, particularly when the air is dry and warm. These beds continue productive for many years, and if the pyrites be pure, but little residuum is left. An excess of sulphuric acid is formed during the process, on which account a quantity of old iron is added to the solution, to saturate it, and obtain the salt in a crystallized state. During the decomposition of pyrites much heat is evolved, and a considerable absorption of oxygen from the atmosphere takes place. The fact was first observed by Henckel, who affirmed, in his "Pyritologia," that air was necessary to the process of vitriolization, and that it enters into combination with pyrites and remains fixed in it: "non ut instrumentum transiens sed immanens." This may be considered as a happy anticipation of one of the most important doctrines of modern chemistry. Some geologists have supposed that subterranean fires, and the temperature of hot springs, are occasioned by the spontaneous decomposition of immense beds of pyrites in the interior of the earth, and an experiment made by Lemery gives some plausibility to this opinion. He found that a mixture of iron filings and sulphur, moistened with a small quantity of water, becomes hot in a few hours, the mass swells, and the parts adhere together: it then breaks with a perceptible noise and crackling, and emits aqueous vapour, and a fetid odour like that of sulpurated hydrogen gas. If the mixture be made in a large quantity, it takes fire in twenty-four or thirty hours. As soon as the emission of aqueous vapour has ceased, the heat becomes greater and greater, is succeeded by inflammation, the smell is then much stronger, and appears to arise from the hydrogen produced by the decomposition of water. Beaumé, who observed this phenomenon from a mixture of one hundred pounds of iron filings, with an equal quantity of sulphur in powder, states that the flames rose to a foot in height, but did not continue longer than two or three minutes; the mass, however, remained red-hot for forty hours. Lemery the elder gave to this experiment the name of the artificial volcano.

Dr. Watson, in his Chemical Essays, vol. i. p. 187, says that he has repeated this experiment more than once. When made in the open air the flame is of short duration, and the whole mass, after the extinction of the flame, continues at intervals to throw out sparks. A ladle full of the ignited mass being dropped down from a considerable height, descended like a shower of red-hot ashes. The success of this experiment depends on a due proportion of water. Half a pound of flower of sulphur, with half a pound of clean iron filings, mixed with fourteen ounces of water, and worked into a paste, will acquire heat enough to make the mass take fire.

Some dark-coloured carbonaceous and bituminous earths contain pyrites in minute grains, and decompose with great rapidity when exposed to moisture. In the month of August 1751, the cliffs near Charmouth, in Dorsetshire, containing a similar kind of pyritous earth, took fire in consequence of a heavy fall of rain after a hot dry season, and continued at intervals to emit flame for several years. Almost all kinds of pit-coal in England contain more or less pyrites: in some the quantity is very inconsiderable, in other kinds it abounds so much as to render them unfit for domestic purposes, and totally inapplicable for forges or iron works, on account of the sulphur which they emit when burned. This pyritous coal may be distinguished by its greater specific gravity, and the brass-like metallic appearance of the pyrites with which it is intermixed. Pyritous coal and coal shale, or bituminous clay, containing pyrites, frequently take fire spontaneously in coal mines, or when exposed in heaps out of the pits, and continue burning many years. Instances of this kind now exist in the north of England; and so intense is the heat produced by the ignition of these masses, that the coal shale is sometimes fused. We have seen specimens from these heaps which have all the characters of cellular volcanic lava. In the vicinity of Leeds there is a large heap of coal shale which has been on fire near half a century; it is covered in parts with vegetation, and presents no appearance of ignition during the day; but if a dry stick be thrust into it the surface is changed in a few minutes. In some of the coal mines in Leicestershire, near Ashby de la Zouch, the stratum of indurated clay over the main bed of coal contains so much pyritous matter, and is so subject to spontaneous inflammation when it falls down and is intermixed with small coal and moisture, that the miners are obliged to close up the space with brick-clay where the coal has been worked, to prevent the access of air to the combustible matter. In this state, excluded from the air, the pyritous earth sometimes becomes ignited, as is evident by the heat communicated to the neighbouring parts of the mine; but the fire is prevented from spreading among the coal, by the precautionary measure of closing the cavities with clay.

The great heat evolved during the decomposition of

pyrites, may proceed in part from the combination of oxygen with the ſulphur and iron, and may be increaſed by the different capacity of the new compound for heat. Whenever chemical changes take place rapidly, they produce a change in the temperature of ſubſtances, as in the well-known inſtances of lime and water, nitric acid and vegetable oils, &c.

The phenomena accompanying the mud volcanoes in various parts of the world, preſent many appearances which give probability to the opinion, that they proceed from the decompoſition of pyritic ſtrata. See VOLCANO.

The formation of alum is alſo effected naturally, in many ſituations, by the decompoſition of pyrites, the ſulphuric acid combining with the alumine of pyritous clay. This is not unfrequently the caſe in excavations of coal mines that have been long worked out.

At Hartlet, near Glaſgow, in the excavations of an old coal mine that has been worked ſome centuries, there is a very extenſive formation of alum, from the decompoſition of the roof of the pit. It is a pyritous clay ten inches thick. In the old workings of the mine which are dry the air circulates ſlowly, and the roof gradually decompoſes and exfoliates, and falls upon the floor, in which ſituation the decompoſition proceeds, and the ſubſtance aſſumes the appearance of a ſpicular efflореſcence. In time the whole ſpace to the roof is filled; it is then removed. The maſs conſiſts of earth richly impregnated with ſulphate of alumine, ſulphate of iron, and in ſome inſtances with ſulphate of magneſia. The coal in this mine, contrary to the uſual practice, is worked to the dip, ſo that the old workings are always dry. To this circumſtance may principally be attributed the great accumulation of alum in this mine. In many of the mines in England a ſimilar formation of alum would take place, but they contain too much water to permit the ſalme ſubſtances to remain. In general, alum rock or alum ſhale require to be expoſed in heaps, and burned in the open air, to expel the ſulphur, and combine it with the oxygen from the atmoſphere. The ſulphuric acid thus formed unites with a requiſite portion of the clay during the proceſs.

The gypſum, or the ſulphate of lime which occurs in beds, among ſecondary ſtrata of red ſand-ſtone and beds of marle, probably may owe its preſent ſtate to maſſes of pyrites, which have exiſted over common lime-ſtone, and been decompoſed naturally. The ſulphuric acid thus produced would unite with the lime, and form gypſum. The great quantity of the red oxyd of iron which is in the ſtone and marle that accompany this kind of gypſum, gives much probability to this opinion. The cryſtals of gypſum or ſelenite found detached in beds of clay had probably a ſimilar origin.

Sulphuret of iron may be formed by heating together iron filings and ſulphur. From the experiments of Vauquelin it is proved that there are four ſulphurets of iron, according to the degree of heat and other circumſtances under which the combination may be formed. The firſt ſulphuret conſiſts of

$\left.\begin{array}{l}78\ \text{Iron}\\ 22\ \text{Sulphur}\end{array}\right\}$ Artificial.

The ſecond ſulphuret, of

$\left.\begin{array}{l}64\ \text{Iron}\\ 36\ \text{Sulphur}\end{array}\right\}$ Natural magnetic pyrites.

The third ſulphuret, of

$\left.\begin{array}{l}54.16\ \text{Iron}\\ 45.84\ \text{Sulphur}\end{array}\right\}$ Artificial.

The fourth ſulphuret, of

$\left.\begin{array}{l}47\ \text{Iron}\\ 33\ \text{Sulphur}\end{array}\right\}$ Natural common pyrites.

When the quantity of ſulphur does not exceed 40 *per cent.* pyrites is ſoluble in muriatic acid, and may be rendered permanently magnetic. The ſpecific gravity of common pyrites is from 4.60 to 4.83. Of magnetic pyrites 4.51.

Arſenical pyrites, called marcaſite, is diſtinguiſhed from iron pyrites by its colour, which is a ſilver white, and by yielding a ſmell like garlic when rubbed or expoſed to heat. See ARSENIC *Ores*.

Auriferous pyrites, or iron pyrites, with a ſmall alloy of gold: the richeſt ſpecimens of this ore in Europe are found in Tranſylvania, containing from 0.02 to 0.03 of gld. Theſe ores are diſtinguiſhed from iron and copper pyrites by their colour, malleability, and ſpecific gravity.

Tin pyrites. See TIN *Ore*.

The pyritæ, in ſubſtance, are never uſed medicinally; nevertheleſs, in their products they are very important. From theſe common ſulphur is extracted, in Sweden and Saxony; the native vitriols are produced in caverns of the earth, or on its ſurface; the greateſt quantities of artificial vitriol are prepared; and the mineral waters, vitriolic, aluminous, ſulphureous, hot or cold, are ſuppoſed to receive their impregnation.

When the matter of the pyrites is mixed with the lead ores, the method of ſeparating the metal by aſſaying is this: roaſt two centners of the ore, as in the uſual method, and keep a ſtronger fire than when the ore is pure. The pyrites, eſpecially when it is merely iron, hinders ore from eaſily growing clammy or turning into large lumps, or entirely melting. When the ore is ſufficiently waſhed, let it cool, beat it to powder, and repeat the roaſting to a third fire, till when it is red-hot in the fire, there is no ſmell of ſulphur; then mix the ore with ſix centners of the black flux, and two of ſandiver, and finiſh the work in the common way, only making the fire greater, and continuing it longer, toward the end of the operation. Cramer's Art of Aſſaying, p. 292. See LEAD *Ore*.

PYRITES is applied by ſome authors to the marcaſite ores of all metals; the names of which are varied according to the metals they partake of.

Thus *chryſitis* is that of gold; *argyritis* that of ſilver; *ſideritis* that of iron; *chalcitis* that of copper; and *molybditis* that of lead, &c.

Quarry

QUA'RRY, in *Agriculture*, the common name of an opening, pit, drift, or ſhaft, which is dug into the earth or ground, and from which are to be raiſed ores of various kinds, different ſorts of ſtones, ſlates, and other materials of ſimilar natures. It is remarked by the writer of the work on "Landed Property," that the more uſeful and advantageous materials and ſubſtances that have at different times been dug and raiſed out of quarries in this country, are chiefly thoſe of the iron ore kind, lime-ſtone, and other calcareous matters, materials for building, ſuch as ſlates, flags, ſtones, and ſubſtances of other ſorts, matters for the conſtructing and repairing of roads, as ſand, gravel, and others of the ſame nature, earthy ſubſtances for the purpoſes of different manufactures, ſuch as clays, &c. moulds and vegetable earthy matters, and coals, with other articles for uſe as fuel. There are, however, occaſionally raiſed from openings of this nature, a few other kinds of ſubſtances, ſuch as will be noticed below.

It has been farther ſuppoſed by the above writer, that the ſubſtances which he has here mentioned, may with truth be ſaid to be of more real uſe and value to mankind than all the mines of precious metals in the world; and that the eyes of the managers of landed eſtates ſhould conſtantly be turned towards and fixed upon the diſcovery of the hidden valuable treaſures and productions of this nature, wherever there is a probability or likelihood of their being to be met with. It is alſo ſuggeſted, that it would be highly beneficial and advantageous if mineralogiſts, and thoſe who are acquainted with ſuch ſubſtances, were to turn their attention towards the appearances or accompaniments which point out ſuch uſeful concealed matters; as it might greatly facilitate the ſearch for them, and frequently lead fortuitouſly to their diſcovery. The methods which are practiſed in ſearching for and aſcertaining the preſence of different ſorts of mate-

rials of this nature, are principally thofe of boring, by means of an auger or borer made for the purpofe, into the earth, and digging into it in other ways. In fearching for moft forts of mineral fubftances, coals, and fome other matters, the ufe of the borer is conftantly firft had recourfe to, and not that of finking a fhaft, however favourable the appearances of the place may be for the purpofe, and the fuccefs of the undertaking. The ground is firft tried by this means, and a certainty of fuccefs or failure gained, as well as that of the moft proper fituation for finking the fhaft or making the opening or pit, without much expence being incurred, in cafe of the former. In trying for ochres, marles, and other fimilar articles, the fame implement is alfo in common ufe. But in raifing and providing lime-ftone, free-ftone, flags, and flates, &c. in fome cafes, digging down into and opening the ground, by fpades and other tools, is the mode employed in the firft inftance, in confequence of fuch fubftances being obvioufly prefent in fufficient quantities to be wrought with advantage. See Borer, Boring, and Auger.

The common methods of working and managing different forts of quarries, are in general, in moft places, tolerably well underftood and regulated, by fuch quarrymen as are conftantly employed in the bufinefs; but a circumftance which they commonly neglect very much, or are in a great degree inattentive to, in many cafes, is that of making good the ground below, by means of the turf or foil which is caft off from the top, or upper parts; and that of keeping the mouths of the openings fufficiently clear and free. Another common difficulty incident to them, is that of draining, and freeing their bottom parts from injurious water. This may be effected in various ways, as by the ufe of different forts of machinery worked by wind, water, and fteam, and by fome other means. See Quarries, *Pits*, &c. *Draining of*.

In many of the more fouthern diftricts of the kingdom, and ftill more in thofe towards the north, and in Wales, there are quarries, from which fubftances of fome of the following kinds are raifed and ufed in their neighbourhoods, or fent away to a diftance, in a very extenfive manner; fuch, for inftance, as thofe of the ftony kind, as iron-ftone or ore, lime-ftone, marble, chalk, granite, free-ftone, grit-ftone, flag-ftone, white, grey, purple, and blue flate-ftone, fand-ftone, fand, gravel, clay-ftone, fcythe-ftones, tile-ftones, &c.; different ochres, plumbago or black lead, calamine, gypfum, marle, pipe-clay, alum-earth, fuller's-earth, peat-earth, culm, coal, cannel, falt-rock, &c. Thefe quarries and pits are wrought, and the materials got up from them, in feveral different ways, according to circumftances and convenience, as well as the particular nature, kinds, qualities, &c. of the different articles themfelves; all of which are moftly well known, and capable of being performed by the workmen of their refpective neighbourhoods, who are commonly employed in them, and very expert in their management.

Stony fubftances which bear a great variety of different names, and which poffefs equal variety in their qualities and ufeful properties, are met with, and dug up from quarries and pits, in many different diftricts and fituations, in almoft all parts of this ifland, in order to be converted to purpofes of improvement and utility in a variety of different ways and intentions. Iron-ftones and ores abound more in the northern parts, though they are occafionally found in fome of the fouthern ones. A confiderable quantity of highly rich iron-ftone is got up and fent annually from the vicinity of Combemartin in Devonfhire, to the iron-works of Mr. Raby at Llenethy in South Wales. A large portion of it is alfo found on the borders of the Orchment river, and difperfed throughout the whole diftrict, as well as in other parts of the fame county. Iron-ftone is likewife met with in Suffex in large quantities, imbedded with lime-ftone and fand-ftone, that which rifes near to the furface being the beft, the other having a coarfer and more dull appearance, working heavier in the furnace. The very beft is frequently interfected with thin ftripes of foft marly matter. Iron-ftone, to a great extent, exifts on the eftates of lord Dudley, and many others in Staffordfhire, and contributes much to the employment and profperity of the inhabitants. But, in the northern part of Lancafhire, in the diftrict of Low Furnefs, ftone and ore of this fort are perhaps found in the largeft quantity, of the beft kind, and in the moft general manner, of any where in the kingdom. There are numbers of fhafts, quarries, and pits for raifing them from, on Lindal Moor, Whittrig Moor, and Crofs Gates, in the vicinity of Dalton, as well as in fome other places. In the former, the working is ufually effected at the depth of from twenty to forty-five feet, but it has been done at lefs as well as greater depths. The whole of their cavities are chambered with wood, and coft from a guinea to twenty-five fhillings in finking each fathom, without the wood. The ore runs in veins or feams between the rocks on the north and fouth, being in breadth from about forty to fixty yards. And it conftantly dips towards the fouth-eaft at the rate of about a foot in five or fix. The beft ore is that which has the moft greafy appearance, and it is raifed with lefs difficulty, working lefs hard, requiring lefs flux, and forming a more foft iron. It is raifed from the fhafts or pits by machinery of the gin or windlafs kind, the men employing picks, punches, and hammers in digging it up. It was formerly got, in fome places, by driving levels into the fides of the hills, and conveying it out on railways, in fmall waggons; but now the other way is moftly employed. Four men get about fourteen tons in the day, in fome fituations; but in others, double the number are required for getting the fame quantity. It is wheeled to diftant heaps, from which much of it is fent in fmall carts to the port of Old Barrow, from whence it is fhipped to different parts of England, Wales, and Scotland, at the expence of from fourteen to thirty fhillings in freight; and the reft converted into pig-iron by the furnaces in the neighbourhood. Iron-ftones and ores are alfo met with in fome other counties more to the north of the kingdom, where there are pits and quarries for raifing them from.

Lime-ftone is a very general fort of ftone raifed from quarries and pits in many different parts of this country, as in Devonfhire, Suffex, Kent, &c. towards the fouth, where it lies in vaft beds, from which it is dug for ufe; in the more midland counties, as in Gloucefterfhire, Shropfhire, Derbyfhire, Staffordfhire, and others, where it exifts and is employed to a ftill greater extent; but by far the moft extenfively in thofe farther to the north, as Lancafhire, Weftmoreland, Yorkfhire, Cumberland, and fome diftricts of Scotland. In many parts of the county of Lancafter it is dug and raifed from quarries, where it lies in a ftratified manner at no great depth from the furface, being got up without much difficulty or trouble; while in other places it is forced from the folid rock, with great labour and expence. This is likewife the cafe in many other diftricts. Wherever it is met with, it is almoft conftantly a quarry material of great value, and which affords much employment to labourers.

In the county of Kent, the banks of fome of the large rivers are fcooped out into ftone quarries in a remarkable manner, fome of them worn out and difufed, others in the ftate of being wrought. It has been obferved, that this is the neareft ftone country into which water-carriage can penetrate from the metropolis; and that the original London

was built, as well as the modern one chiefly paved, by materials from this diſtrict, ſuch as the rag-ſtone, and the large pebbles gathered on the ſea-ſhores, before the Scotch granite came into uſe. In the neighbourhood of Maidſtone there are the appearances of many abandoned and neglected quarries of this nature; but the moſt conſiderable ones, which were lately wrought in that vicinity, are thoſe of Farleigh and Fant. In each of theſe, blocks of ſtones, of different kinds, and of every form and ſize, are met with, being ſeparated by ſeams, and large irregular maſſes of earth of various qualities: among the reſt, brick-earth of the beſt quality. In ſome places, the ſtones are buried ſeveral feet under theſe earthy materials; in others, the rock riſes to the ſurface. After this, the quarrymen worm their way; following it, with irregular windings, leaving behind them refuſe in greater quantity than the uſeful materials which they raiſe.

The ſtony ſubſtances which are principally met with in them, are of two very diſtinct kinds: the one hard, and of a ſtrong contexture, provincially denominated *rag*, or Kentiſh rag; the other of a ſoft crumbly nature, provincially termed *haſſock*. The quarrymen are in the practice of dividing the firſt ſort into two kinds; what they call the *common rag*, and the *cork-ſtone*, the latter being their principal object in theſe immenſe works. It has in its general appearance much reſemblance to the ſtrong grey lime-ſtones which are found in different parts of this country; but when minutely examined by means of a glaſs, its fracture and contexture have the characters of the Devonſhire marbles; except that the grain of this ſort of ſtone is ſomewhat coarſer. In colour, too, it differs from theſe marbles, having a greater reſemblance to the Yorkſhire lime-ſtones. It is uſed for different purpoſes; much of it is ſent to the neighbourhood of London, where it is burnt into lime, for the uſe of the ſugar-bakers; who, for ſome reaſon or other, chiefly employ lime, burnt from this material, or ſtone, inſtead of that of chalk. It is likewiſe made uſe of as a building material; and, particularly in pedeſtals, for the poſts of cattle-ſheds and other farm-offices. It is hewn with ſtone-maſons' axes, working with tolerable freedom.

It is very durable, as ſome part of the baſement of Weſtminſter Abbey appears to have been built with the ſtone from theſe quarries. In this caſe, it ſeems to have been dreſſed ſmooth; and the ſurface ſtill remains with little alteration; having withſtood the attacks of time with great firmneſs; it being even now difficult to detect a looſened ſplinter in the work.

The common rag-ſtone comprehends all the different kinds which are met with in theſe quarries, except that of the above, and that which is of the haſſocky nature; though the true unmixed rag is a diſtinct ſort, having characters different from any of the others. In the colour, it inclines more to the red or liver colour, than that of the cork-ſtone, but otherwiſe reſembles it conſiderably. Viewed with a glaſs, its grain is finer, and the fracture flint-like.

Its uſes are, however, but few. Some of the beſt and moſt regularly-faced ſtones are ſometimes laid aſide for paving materials; but the large pieces are moſtly reſerved, in order to be ſent by water to the diſtrict of Romney Marſh, for the purpoſe of forming the hard materials of the embankments and jetties, which are there made againſt the ſea. The ſmaller ſorts are, in general, converted to uſe as a road material.

The haſſocky ſtone appears to the naked eye to be of a ſoft, white, ſandy quality; and its fracture is the ſame But under the glaſs, its grain is fine. its contexture uniform, and ſo thickly interſperſed with ſmall ſeed-like granules, of a dark or black colour, as to give it a grey appearance. Sometimes bearing evident impreſſions of ſhells. Its texture is looſe and brittle; crumbling eaſily between the fingers into a coarſe ſand-like powder. It will not burn into good lime, although it is almoſt wholly calcareous.

Its principal uſe is that of forming a looſe friable ſort of rubbly ſub-ſoil, in ſome places, which is admirably ſuited to the growth of ſaintfoin, and ſome other crops of the plant as well as the fruit-tree kinds.

The quarries in ſeveral other counties contain ſtony materials of theſe different kinds, which are wrought and applied to a variety of different uſes in theſe and other ways.

Quarries of marble are wrought in ſeveral diſtricts in different parts of the country, and afford great advantages in various ways. In Suſſex they have a marble, which, when cut into ſlabs, is uſed for ornamenting chimney-pieces, and many other purpoſes. It is equal in quality and beauty to moſt ſorts when highly poliſhed. For ſquare building and paving it is alſo a material ſcarcely to be exceeded. By burning, it likewiſe affords a very valuable manure, equal, and by ſome thought ſuperior, to chalk, being cheaper to thoſe who are near the places from which it is dug. It is found the moſt perfect about Kirdford, at the depth of from ten to twenty feet underground, in flakes nine or ten inches in thickneſs, and called the Petworth marble. It was much employed in building the cathedral at Canterbury, the pillars, monuments, vaults, pavement, &c. being formed of it. And the archbiſhop's chair is one entire piece of it. Marble is gotten in ſome of the counties in the middle of the iſland, as Derbyſhire, Nottinghamſhire, &c. At Beacon-hill, near Newark, a blue ſtone for hearths is got, which approaches to marble, and is capable of burning into lime. And in the county of Derby much good marble is raiſed in different places. In Lancaſhire there are quarries of fine black marble, and of ſtones, which approach to, and take on the poliſh of marbles. In many of the weſtern and northern parts of Yorkſhire, marble of various kinds is found, ſome much reſembling, and others ſuperior, in cloſeneſs of texture and diſtinctneſs of colours, to that which is wrought in Derbyſhire. Alſo a ſtone, which greatly reſembles the marble of that county, and which is capable of receiving much ſuch a poliſh, and is nearly of the ſame colour, mixture, and appearance. On the ſide of the river Kent, near Kendall, a vein of beautiful marble has been lately diſcovered in the property of D. Wilſon, eſq. of Dallam-Tower; and a main quarry opened upon it. Marble has alſo been met with on the oppoſite bank.

In the county of Inverneſs, likewiſe, marble of the greateſt variety of colours, and of the moſt beautiful ſhades, has been met with in Benevis, on the property of Mr. Camerton; and inexhauſtible quarries of it lie untouched in the iſlands which belong to it.

Beſides, this ſort of material exiſts in immenſe quantities, in quarries, in many other parts of the kingdom.

Chalk is a material which is raiſed from quarries and pits, moſtly in the ſouthern parts of the country, as in Suſſex, Surrey, Kent, Eſſex, Berkſhire, Hertfordſhire, &c. It exiſts in vaſt ranges and tracts in moſt of theſe diſtricts, whence it is dug up from quarries, at different depths, according to circumſtances, expoſed in ſheds to dry, when wet, and then converted into lime for various uſes, by means of fire, or employed in its broken and powdery ſtate, without undergoing the above proceſſes, by merely digging it out of ſuch places. In ſome parts, as in Kent, and the neighbouring diſtricts, it is often dug and raiſed from conſiderable depths, from beds of very great thickneſſes. And near Reading, in Berkſhire, there is a ſtratum of this ſub-

ſtance, which is thirty feet in thickneſs. It is there uſed and dug out for manure, and occaſionally as a building material, for the latter of which purpoſes it is very durable. The remains of the abbey of Hurley, and of the ancient chapel, now the pariſh church, built wholly of chalk, in the reign of William the Conqueror, are, it is remarked by the writer of the corrected Agricultural Survey of the diſtrict, ſtill as freſh and ſound as if they had been the works of the laſt century. Chalk, when once indurated by the air, has a remarkable property in reſiſting the action of the weather.

Granite is a ſtony ſubſtance, which is found to exiſt in ſome of the ſouthern parts of the country, as well as in thoſe of the north, but it abounds much more in the latter.

In the weſtern parts of Cornwall it is in great plenty in the diſtricts of Penwith and Kirrier, preſenting itſelf in large ſlabs on all the rocky hills or tors, as well as in the waſte moors and vallies; and appearing in detached ſpots, even in the ſhelfy ſlaty tracts. It is of different colours and textures, being adapted to a great variety of uſes and purpoſes, as thoſe of building, and being wrought into columnar maſſes, eight or ten feet in length, for ſupporters to ſheds, out-houſes, &c.; and as gate-poſts, and bridges over brooks, rivulets, &c.; as well as in the forming of rollers, malting, ſalting, and pig troughs. It is alſo an article of commerce to different parts. It is ſuppoſed to be exactly of the ſame nature with the original granite; and there are five ſorts of it, which are diſtinguiſhed by their colours, the white, the duſky, or dove-coloured, the yellow, the red, and the black, moſt of which are charged with a brown and bright ſilvery matter.

The county of Inverneſs has a great deal of this ſort of ſtone, and there are numerous quarries in it for raiſing and working of it. The common granite abounds in all the different diſtricts of it. In many places the whole rocks are compoſed of this kind, which is uncommonly uſeful for all ordinary purpoſes. By natural fiſſures, which run in ſtraight lines, and generally at right angles, it is formed into all ſized portions and ſhapes, having uniformly a plain ſurface. And, by means of cutters or tranſverſe lines, theſe ſtones are eaſily quarried, and found in the greateſt plenty every where. They are remarkably beautiful, being almoſt as ſmooth and regular as hewn ſtone, and of courſe well ſuited for various ſorts of building work. The beſt buildings of the county-town are of a dark kind of granite, which is very hard and durable, but which has few or no fiſſures. It is generally found in large blocks, and in many of theſe parts, there is no other material for building or adding ornament with. The manner of giving it the poliſh it admits of at the quarries, is by means of ſmall picks, or pick-axes, which are, in fact, hammers with ſharp points at each end, in the manner of thoſe employed by millers in preparing their grinding ſtones. It is a very heavy, compact ſtone. There is a mixed ſort, denominated peaſy granite, which conſiſts of white, black, and grey ſpots, that ſparkle beautifully in the ſun, and is very ornamental, as well as much uſed for different purpoſes, as ſtairs, doors, and windows. Though this is very ſolid, and almoſt without natural fiſſures, it ſplits very ſtraight, by means of iron wedges, ſet in a line, and ſtruck alternately, with a hammer of great power.

A great deal of this kind of ſtone is imported into the metropolis and other large towns, for paving the ſtreets, &c. It is on the whole a very advantageous ſort of quarry material in various parts of the kingdom.

Quarries of free-ſtone are wrought in a great number of different places. In the more ſouthern parts is found the Portland ſtone, which is ſo famous and uſeful in building. A ſort of this kind of ſtone, which much approaches to it in quality, is alſo met with in Cornwall. Some likewiſe exiſts in Devonſhire and Glouceſterſhire. The Cotſwold quarries in the latter, afford free-ſtone of an excellent quality, particularly thoſe at Painſwick, Lodbury, Lockhampton-hill, &c. It abounds more, however, in Cheſhire, Lancaſhire, Weſtmoreland, Cumberland, and ſome of the ſtill more northern diſtricts. Several excellent quarries of free-ſtone are carried on in the firſt of theſe, as thoſe at Runcorn, Manley, &c. where much valuable ſtone of this nature is raiſed. The ſecond county alſo affords equally valuable quarries in many different places, from which vaſt quantities of the ſtone are raiſed, and employed, or ſent away to a diſtance. Thoſe about Ormſkirk, Up-Holland, and Wigan, as well as thoſe on all the eaſtern ſide, are in general of a very good quality. And in the vicinity of Lancaſter there are ſome excellent ones; that on the moor or common, cloſe to the town, is very extenſive, and affords a free-ſtone that admits of a fine poliſh. In this diſtrict, this ſort of ſtone is met with of a whitiſh-brown, yellowiſh, and reddiſh caſt, but the firſt is by much the moſt eſteemed. In the eaſtern parts of Weſtmoreland, as about Hutton Roofe, and ſome other places, a good ſort of free-ſtone is dug up from pits and quarries formed for raiſing it. This ſort of ſtone exiſts and is quarried almoſt all over the counties of Cumberland and Northumberland; and prevails occaſionally in others, where it is wrought to advantage. A grit-ſtone, ſomewhat of this nature, is met with in ſome diſtricts, as in Shropſhire, &c. which is raiſed from quarries, and uſed as a building material. And a ſand-ſtone exiſts to conſiderable extent in others, as in Suſſex, &c. that is ſometimes dug up, and made uſe of for common buildings, &c. In Cheſhire, on the hills near Macclesfield, about Kerridge, a ſort of ſand-ſtone is met with, which is particularly well ſuited to the making of flags, and whetting tools, as well as ſometimes to the forming of ſlates, for which it was formerly much employed. Near Pott-Shrigley, alſo, a fine ſand-ſtone is found, that admits of a good poliſh. The quarry has not, however, been wrought for ſome late years, as from the extreme hardneſs of the ſtone, the expence of getting it is very conſiderable. There are ſeveral other quarries of excellent free-ſtone wrought in the ſame neighbourhood.

There has been great abundance of free-ſtone wrought, time immemorial, in the low parts of the county of Perth, and quarries of a greater or ſmaller grained ſtone of this ſort appear almoſt in every place, with the exception of the carſes. In the lowlands, and near to the eaſtern ſea, the pores and grain of it are greater; but as the mountains are approached, the pores are leſs, and the grain finer, by which theſe ſtones admit a ſmoother poliſh. The quarry of Tullyalan pariſh, called Long-annat, affords a ſtone of a very excellent quality. It has a white colour, admits of a ſmooth poliſh, and reſiſts the influence of the weather. Some of the principal houſes in that part of the country, as well as ſome of the moſt magnificent public buildings in the capital of Edinburgh, as thoſe of the Exchange, the Infirmary, and the Regiſter-office, conſiſt partly of this ſtone, and thoſe found at hand. And farther, in ſome inſtances it has been carried to the continent. But the quarry of Kingoodie, in the carſe of Gowrie, belonging to Mr. Mylne, of Mylnfield, is unqueſtionably the fineſt of this kind of any in the county. Aſtoniſhing blocks in great number are raiſed there, fifty feet in length, ſixteen feet in breadth, and three feet in thickneſs. Such is the demand for this ſtone, both at home and abroad, that four veſſels are employed in exporting it from this quarry. The work is, however, on the de-

cline, occaſioned by the act of 1794, which impoſed a duty on ſtones, which, although trifling in itſelf, cauſes much grievance, vexation, delay, and trouble, in procuring coaſt-diſpatches, &c.

Flag-ſtones and quarries for the working and preparing of all ſorts of flags, are met with in all thoſe ſituations where free-ſtone is found, and where it exiſts in rather thick ſtrata, or layers of ſome depth, which are capable of being ſeparated by hammers, wedges, or other means. In many places in the ſouthern parts of the iſland, the flags raiſed from ſuch free-ſtone quarries are of an extremely good quality, being uſed in very large quantities for many different purpoſes. Thoſe of Cornwall and Devonſhire alſo, in many caſes, afford a good ſort of flags. The ſand-ſtone quarries of Shropſhire, as at Grinſell, near Shrewſbury, about Bridgnorth, and at Corndon-hill, near Biſhop's-caſtle, as well as in the Swinney mountain, &c. where alternate beds of fine white and red ſtone of this kind, of very ſuperior quality and thickneſs, exiſt; that in the firſt of theſe ſituations, being twenty yards thick, affords flags likewiſe, which are of a very uſeful nature. Free-ſtone flags too, of uſeful ſorts, are met with in the quarries of ſome of the midland counties. And they abound much in many of the free-ſtone quarries of Lancaſhire, Yorkſhire, and ſome of the other more northern diſtricts of the country.

The quarries of this kind become ſlate-ſtone, and furniſh the white, grey, and brown ſlate, wherever the ſtone lies in thin layers, or ſtrata, which are able to be raiſed and ſeparated from each other with convenience and facility. They exiſt in moſt of the above tracts, and are plentiful in ſome of them, eſpecially thoſe towards the north. The Lancaſhire and Yorkſhire quarries, in many places, ſupply the white and grey ſorts in great abundance, and of good qualities. Thoſe of Weſtmoreland, Cumberland, and Northumberland, alſo afford them in many inſtances of a valuable nature. And they are equally good in the ſtill more northern diſtricts. There are numerous quarries of different colours of them in Clydeſdale, Perthſhire, Argyleſhire, and the county of Inverneſs, from which vaſt ſupplies are conſtantly raiſed for home and other uſe. This ſort of ſlate has, however, moſtly the diſadvantages of being very porous, heavy, leſs durable, and of requiring more and ſtronger timber to ſupport it, than ſome other kinds; being only fit for expoſed climates and ſituations.

The quarries of the lighter and thinner kinds of ſlate, of the blue, green, purple, and other colours, formed from other ſorts of ſtone, only exiſt in ſome particular diſtricts, as thoſe of Wales, the northern part of Lancaſhire, and the adjoining counties, and in a few places in Scotland. The ſlate quarries of the Welſh diſtricts ſupply ſeveral kinds and colours in large quantities, and of good qualities, but the dark and lighter purples are the moſt prevalent ſorts in moſt of them. In Lancaſhire the quarries of this kind are very numerous in the part to the north of the ſands, as about Gothwaite-common, Kirby-moor, Coniſtone-hills, and Tilberthwaite-fells, &c.; and from which very large ſupplies of the blue, green, and the dark purple ſorts of ſlate are raiſed, and ſent away for exportation, or conſumed at home for different purpoſes. They are wrought, and the ſlate prepared in ſomewhat different manners in different places. The Gothwaite quarries have the ſlate dug out from the ſide of the hill, and carried away. But in ſome on Kirby-moor, a level is driven through the ground from below, the metal being conveyed away by ſmall four-wheeled waggons on iron rail-ways. Thoſe about Coniſtone are moſtly worked into the hills, and the metal raiſed and carried out from them. Some of the Tilberthwaite quarries are wrought by blaſting the ſlate-ſtone, and collecting and carrying it out of them on ſlanting roads, in ſmall carts or trucks conſtructed for the purpoſe, the levels being below the hills, but not nearly ſo low as the bottoms of the quarries. Others are wrought by draught roads from the bottoms of them. One man will raiſe eighteen or twenty hundred weight of ſlate in one day, where the metal riſes well, but leſs in other caſes. In ſome it is dug out by one ſet of men, ſplit by another, and formed into ſlates by a third, for which purpoſes, flat crow-bars, ſlate-knives, and axes are employed. The ſlate is divided and diſtinguiſhed into three ſorts, as firſts, ſeconds, and thirds, or London, country, and toms. In the firſt, or Gothwaite quarries, the ſlate has a darkiſh purple, or black caſt, and is worth from forty to forty-four ſhillings the ton. In the Coniſtone quarries it has a fine blue and green appearance, and is much thinner and lighter than the other ſort. The Tilberthwaite ſlate, in ſome inſtances, ſplits very fine, thin, and light, but does not cover ſo far as thoſe of the Gothwaite and Kirby quarries. This ſort is worth from forty-eight to fifty ſhillings the ton. In ſome quarries a ſort of rent is paid *per* ton, on the ſlate which is raiſed, as ten ſhillings for the beſt, eight ſhillings for the ſeconds, and ſixpence for the thirds. In others a certain rent only is paid for the liberty of the royalty, and not a tonnage duty. Theſe rents or duties on the workers of theſe quarries, are probably higher than they will bear, and have enabled the Welſh ſlate dealers to underſell thoſe of this county.

Weſtmoreland and Cumberland, in ſome inſtances, afford good blue and green ſlates. In the latter, ſome of an excellent quality are gotten in the quarries of Borrowdale, and inferior ſorts in ſome of the neighbouring mountains.

The county of Argyle, in Scotland, in ſome parts abounds with ſlate-quarries, as the tracts about Eſdale, from which five millions of ſlates have for ſome time been annually ſold at the rate of twenty-five ſhillings the thouſand. Quarries of the ſame kind are alſo wrought in many other parts, with great benefit to the inhabitants.

Slate-quarries are formed in many parts of the highlands of the county of Perth, but none in the low. The ſlates in ſome are of a purple colour, in others of an azure blue, and in a few of a muddy, ſandy, brown complexion along the cutters. It is well known where the different ſorts are quarried. The veins of ſlate-rock ſeem to run from Drumlane, in the pariſh of Aberfoil, in a north-eaſt direction to Dunkeld; and may be traced beyond the limits of the county both ways. The azure coloured are the beſt metal, and riſe of a greater ſize than any of the other kinds. Many of the buildings in different places are ſlated with this beautiful covering. Into the lower diſtricts of the county, ſlates are imported from Eſdale, and the other quarries on the weſt coaſt of the county of Argyle.

Quarries of grey ſlate exiſt in many different parts of the county of Inverneſs, in which the quality is very good, and well ſuited to the climate. In ſome places theſe ſlates are much preferred to blue ones, as the latter are more expenſive in procuring, and though nailed on the roofs ever ſo firmly, are apt to be looſened by high winds, unleſs bedded in lime, which circumſtance renders repairs difficult.

There are numerous quarries of ſand and gravel to be met with in almoſt every diſtrict of the kingdom, which are wrought either for the purpoſe of ſupplying domeſtic uſes, or thoſe of repairing roads, &c. Thoſe of the former ſort, which contain the fine white, red, and yellow ſands, are by far the moſt valuable, and wrought to the greateſt extent, the materials being moſtly dug out from the ſides of banks and other places, and but rarely got by ſinking

the quarries into the more level parts of the ground, though this method is fom times practifed. The matters are commonly raifed fimply by digging and fpades; and thrown into the carts, in many cafes, from the quarries and pits themfelves. Numerous quarries and pits of this nature exift and are wrought to a very great extent in the neighbourhoods of the metropolis, and moft other large towns, all over the kingdom, for the purpofe of fale for various domeftic ufes.

In the gravelly kinds, thofe quarries which abound with the fharp, coarfe, flinty, and pebbly forts, are the moft proper and beneficial for the making and repairing of all forts of roads and carriage-ways. They are occafionally formed by working into banks and fteep places, but more frequently by openings in the plain furface. Their depth is fometimes confiderable, the materials being raifed after being fcreened, the work, of courfe, very laborious and troublefome. In other cafes, the carts are filled from the quarries or pits without much difficulty or trouble.

Quarries of clay-ftone, ftone-tiles, fcythe-ftones, and fome other forts, are found of good qualities in different diftricts. In Gloucefterfhire they have quarries of blue clay-ftone at different depths, lying in beds of the fame coloured clay, difpofed in layers of from four to ten inches in thicknefs. The ftone in new quarries is eftimated by the effects which the atmofphere has upon it from fome expofure. The beft fort is a very ufeful material for feveral purpofes. Quarries of ftone-tiles principally exift, and thofe articles are raifed from them, in different part of the Cotfwolds. The beft are prepared about Miferdine, Beverftone, Charlton, and Hampton-field, the colour of which are yellow or grey; but another fort, which is red grit, is dug up about Iron Acton, and fome other places, but which is lefs valuable.

There are quarries of fcythe-ftones in many parts of Lancafhire, but the beft are obtained from thofe about Rainford, where they are well wrought and prepared for ufe. In feveral other diftricts, quarries of different kinds of whetting-ftones likewife exift, and are wrought to advantage.

Ochres of different kinds are met with in different places in quarries formed for the purpofe of raifing them. In the county of Devon, formerly large quantities of various fhades between red and yellow, were raifed and manufactured in thofe about Eaft-down. Umber, in the parifh of Combemartin, exifts in a pretty large body. The working and preparing of thefe are, however, now much lefs attended to than heretofore.

In Suffex there are quarries of red ochre about Graffham, and in various places contiguous to the fea, as near Chidham, &c. where much is raifed, prepared, and fent to London. Ochre quarries alfo exift in many counties more to the middle and north of the kingdom, from which great quantities of this fubftance are procured and prepared for ufe in different forts of arts and manufactures.

Quarries of plumbago, or black lead, are likewife occafionally found and wrought, in different fituations, in different diftricts of the country. This fubftance has been met with and raifed near the borders of the Bovey river, in Devonfhire, in fome quantity, and prepared to be fent to Exeter for fale. Quarries of black lead are alfo found and wrought in Borrowdale, in Cumberland, near to the town of Kefwick, to fome advantage. And they exift in fome of the middle tracts of the ifland, affording great benefit to the proprietors of them. In the county of Invernefs, there are fome appearances of black or pencil lead about Glengary, but they have not yet been turned to any ufeful account.

In fome diftricts, in the middle parts of the country, quarries of calamine, or *lapis calaminaris*, are met with, and much of this fubftance raifed from them to great profit. It abounds in the Mendip-hills, in Somerfetfhire, about Rowbarrow, Shipham, Winfcomb, and on Broadfield-down, &c. It is fometimes found within a yard of the furface, and feldom wrought deeper than thirty fathoms. In fome places its quality is excellent. It is prefent in other neighbouring mountainous tracts, and raifed with equal advantage.

Quarries of gypfum prefent themfelves in many different parts, and are wrought in fome with confiderable benefit. In the county of Devon, it lies between ftrata of red-ftone, marle, and chalk rubble, about Salcombe, Branfcombe, and Beer, being ufeful for various purpofes. Gloucefterfhire and Derbyfhire have quarries of this nature, where there are fine beds of it. Thofe of Auft Cliff in the former, have it not fo good, however, as that which is met with in the latter county. In Nottinghamfhire it is of an excellent quality, efpecially that got near Newark and at Redhill. Chefhire has fome, but not turned to much account. Weftmoreland and Cumberland have good quarries of it, in fome places, where a great deal is gotten up, and made ufe of. And it abounds in different parts of the county of York, where it is raifed to advantage.

Marle is an article that is met with in pits and quarries in a variety of different fituations, and of feveral different kinds and qualities. It is found and dug up for ufe in many places in Suffex, and the counties more to the centre of the country; but it prevails in the greateft plenty in the county of Lancafter and fome others, in which it is raifed or worked out from large openings on the fides of hills, high banks, or in the plain furface, and fet thickly upon the land. The getting or digging of the material out of fuch places, is ufually performed by means of ftrong iron mattocks, crows, fpades, and wooden fpiles; large pieces being in fome cafes forced down, not without danger to the workmen, by driving in the fpiles or piles from above. This method is called *falling*. The work is extremely fevere, and commonly done by the rod. The large clods thus forced down, break into fmall pieces, and are then filled into carts for the purpofe.

Shell-marle, though it is not much attended to in any part of England, is frequently met with and dug up from various parts of Scotland, and employed on the land in great quantities, with much fuccefs. The pits and quarries of this fort are commonly wrought with much more facility than thofe of the others.

Pipe, and other kinds of fine clays, are dug and raifed from a fort of pits or quarries, in large quantities, in many different counties. Near Wear Giffard, in Devonfhire, much of the firft fort is dug and fent coaftways, though not in fuch quantities as formerly. Brown potter's-clay is alfo raifed and fent away in great abundance from the neighbourhood of Fremington. Thefe forts of clays are likewife found in much abundance in Berkfhire, and ftill more fully in fome of the midland diftricts, where the pits of them are wrought to a vaft extent. They are articles of great importance and utility in feveral forts of manufactures, and for which there is great demand in many inftances.

Alum earth is a kind of ftratified matter, which is met with and raifed from pits and quarries in a number of different fituations, and various parts of the kingdom. In fome they are wrought to very confiderable extents and advantages, but in others in far lefs degrees, and with much lefs fuccefs.

The ftrata of this earth are dug and got up in different

manners under different circumſtances, but moſtly by means of ſtrong crows, picks, and other tools of a ſimilar kind, being wrought in ſomewhat the ſame method as in the caſes of marle. The buſineſs is uſually executed by common labourers.

Fuller's-earth is another material of this nature, which is dug out of the ground from pits and quarries at different depths in ſeveral parts of the country. In ſome it is very abundant, and of a rich good quality, as in thoſe of the middle and more northern parts of the iſland, forming an article of great uſe and demand in ſeveral branches of buſineſs. In others it is of a much leſs valuable nature, being far leſs in requeſt. That which is found about Tillington, in Suſſex, is conſumed in the neighbouring fulling mills. The mills of this ſort in Yorkſhire, and other parts alſo, conſume immenſe quantities. The material is raiſed from the places in which it is found in much the ſame way as many other earthy ſubſtances, but it ſeldom requires ſo much digging, as it is a far leſs hard matter.

Fuller's-earth was formerly got up from pits and quarries in the neighbourhood of Maidſtone, in Kent, and much ground wrought over; but the beds of ſand by which it is covered are of ſuch depths, as to render the works of little value or importance.

Quarries and pits of mineral peat-earth are found in ſome diſtricts, and much of the material dug up from them, and made uſe of when prepared upon land. The vale of Kennet, in Berkſhire, contains vaſt quantities of it, as well as ſome other parts. It is a ſtratified ſubſtance which is dug from under the ſurface at the depth of from one to ſix feet, laying below ſtrata of ſmall ſhells and calcareous matter. In raiſing it, a peculiar kind of ſpade is made uſe of, which cuts it in long pains, ſomething like ſoap, which, when dry, are burnt into aſhes and laid on the land. This ſubſtance is found to contain the oxyd of iron, gypſum, and the muriates of ſulphur and potaſh, in the proportions of forty-eight, thirty-two, and twenty parts to that of one hundred.

It is ſuggeſted by the writer of the work on "Landed Property," that in moſt mountainous diſtricts, and many low fenny counties, immenſe collections of vegetable mould or peat-earth lie in a ſtate of neglect; even in places where they might be converted to valuable purpoſes; not only as ſources of fuel merely, but as manure, either uſing the vegetable matter in its raw ſtate, or after being reduced to aſhes. In all theſe ſituations it might be readily dug up from different places, and applied to different uſes in each of theſe ways, the pits or other ſpots containing it working in a very eaſy manner. The aſhes of it are only employed on any large ſcale in the above county.

Culm, coal, and cannel, are articles of the fuel kind, which are found in a vaſt number of places, all over the kingdom in pits, mines, or quarries, and which are of the greateſt importance in many of them. Speaking of coals, the author of the work on "Landed Property," conſiders them as riſing in the minds of moſt men, far ſuperior to moſt other productions and ſubterraneous matters, whether they are held in the light of agriculture, manufactures, or national defence. It is aſked, if it were not for the collieries of this country, how many hundred thouſand acres of its land, which are now appropriated to cultivation, would be required for the production of fuel? How many manufactories, eſpecially thoſe of iron, which are ſo very valuable to civilized ſociety, would be cramped, retarded, and ſtopped, in their progreſs and operations? And how many hardy ſeamen would be wanting to its navy? Surely, in his opinion, an indigenous production and material, on which the proſperity of the country ſo greatly depends, is entitled to the guardian care of its government; to aſcertain the preſent expenditure, and the probable ſtock which is remaining. Let us not, it is remarked, play the ſpendthrift, and, by the follies of a day, entail centuries of want on generations to come, and the curſes of millions on the memory of the preſent times.

In endeavouring to find theſe ſorts of ſubſtances in parts where pits of them have not yet been wrought, the ſearching, it is ſuppoſed by the ſame writer, ſhould, in general, be done by the land proprietors of the particular places, in conjoint manner. There are, however, certain inſtances, in which individuals may proſecute the ſearch with propriety, and in the moſt beneficial manner. In doing which, the principal things to be guarded againſt are thoſe of miſjudgment and impoſition. Hence the neceſſary prudence of endeavouring to procure perſons of ſkill and integrity for making ſuch ſearches; which are, in the firſt place, to be attempted by a cloſe inveſtigation of ſuperficial appearances, and then where thoſe are favourable in their nature, by the uſe of the boring rod or tool. It is ſuppoſed that, at preſent, there are none who are equal to ſuch undertakings, except thoſe who have been long converſant with the buſineſs of coal-works; men who have an intereſt in the exiſting collieries or works of that kind. On this account it is thought to become a matter of common prudence, in a given ſituation, to endeavour to procure an undertaker or overlooker from a diſtant work; or ſuch a one as can have no counter-intereſt to that of his employer; and then, cloſely to connect and bind them in one common intereſt. After having had different occaſions for conſidering the ſubject, and for beſtowing no ſmall thought upon it, the writer is of opinion that the moſt eligible plan of proceeding, in ſuch caſes, is that of agreeing with an overlooker, or undertaker, to pay him reaſonably, but not extravagantly, for his time, and for his actual expences in proſecuting the neceſſary ſearches; and, further, to agree to give him, in the event of ſucceſs, a reward ſufficient to call forth his beſt exertions; ſuch reward to be payable, not on finding coal, but whenever the work, to be eſtabliſhed in conſequence of the diſcovery, ſhall have cleared the amount. In this way the proprietor will feel himſelf ſecure, while the perſon employed has the moſt powerful ſtimulus to induſtry, attention, and the accompliſhment of the object of the undertaking.

Culm and coal have been met with and wrought in ſome degree, in Devonſhire, Suſſex, and ſome other of the ſouthern parts of the iſland; but they exiſt much more plentifully in the midland and more northern diſtricts, as well as in ſome places in Wales and Scotland. In Glouceſterſhire, coal abounds in moſt parts of the foreſt of Dean, and its vicinities, and probably to within a ſmall diſtance of the county-town, as at Newent and Pauntley, where pits are eſtabliſhed. Thoſe of the foreſt tracts are very numerous, but not fully wrought for want of ſufficient draining. Pits of this kind alſo exiſt in many places, in the lower vale part of the county. In this diſtrict, however, the coals are no where of the beſt quality.

In the counties of Salop and Somerſet, coals alſo prevail very much, various pits of them in both, being wrought to conſiderable extent. Thoſe in the northern part of the latter diſtrict, have ſtrata of them which form an inclination of the plane of about nine inches in the yard; and are nineteen in number. They are ſeldom wrought where leſs than fifteen inches in thickneſs, but they vary from ten inches to upwards of three feet. The working is performed at conſiderable depths, eſpecially ſince the eſtabliſhment of improved machinery, and other means for raiſing them. The

coal is of the firſt quality, being pure and durable in burning, and from its firmneſs, largeneſs, and ſtrength of grain, capable of being conveyed to any diſtance without injury. At preſent the quantity raiſed in theſe pits, is from fifteen hundred to two thouſand tons weekly, but much greater ſupplies could be afforded, if they were wanted. The works are twenty-ſix in number, ſome of which afford a good profit.

The pits in the ſouthern part are upon a more limited ſcale of work. In them the ſtrata of coal form an inclination of the plane of from eighteen to thirty inches in the yard; but in ſome it is deſtroyed, and they deſcend in a perpendicular manner. There are, in number, twenty-five, which are in thickneſs from ſix inches to ſeven feet, being rarely wrought under eighteen inches. The depth of working is middling, but will be increaſed. The quality of the coal not the beſt, but tolerably good. The quantity now raiſed from theſe pits is from eight hundred to a thouſand tons in the week, which might be eaſily extended. The working profits are by no means great. There are pits in other parts, but they are not many, or much wrought.

Againſt the apprehenſion of pits of this nature being exhauſted or worn out in theſe places, it is contended that more than treble the preſent quantity is capable of being raiſed from the works already carried on, and that this increaſed quantity might be ſupplied for ſeveral hundred years to come.

The works and quantities of coals contained in the counties of Stafford, Derby, and Nottingham, are likewiſe very great, and moſtly of good kinds; pits of them being carried on in many places to vaſt extent.

Cheſhire, too, is a coal diſtrict, in which a great variety of works for raiſing it are eſtabliſhed in different parts, and much of it, which is of a very good quality, gotten up. The ſtrata of coal here in many caſes are ſeveral feet in thickneſs; about Wirrall the ſeam is five or ſix feet thick, and the works extenſive under the channel of the Dee. In ſome works the beds of coal lie at the depth of from ſeventy to one hundred yards below the ſurface of the ground, and are of different thickneſſes to ten feet or more.

In Lancaſhire, coal of good ſorts is moſt abundant. The beds of it run acroſs the county in ſomewhat three different parts, as towards the ſouth, nearly in the middle, and on the north-eaſt part. Thoſe in the two firſt are of conſiderable breadths and thickneſſes in different parts, but the third is much leſs broad and very thin in many places. They all run, in ſome degree, from the north-eaſt to the ſouth-weſt, conſtantly keeping ſomewhat the ſame direction, though occaſionally branching out in a lateral manner to ſome extent. The works on each of theſe different lines of coal ſtrata, eſpecially the two moſt towards the ſouth, are very numerous, and, in different inſtances, of very conſiderable extent. There are ſome alſo eſtabliſhed on the northern line, but they are of a far more limited nature. The layers or ſtrata of the coals are of various widths, from a few yards to a very great diſtance, and their depths or thickneſſes from a few inches to ſix or ſeven feet. They lie at very different depths from the ſurface of the earth, according to circumſtances and ſituation; on the eaſtern ſide of the county they ſometimes nearly appear on the top of the ground, while in the middle, and towards the ſouth-weſt, they are often a conſiderable number of yards deep. All about moſt of the large towns in the ſouthern parts of the diſtrict very extenſive works are eſtabliſhed, where immenſe quantities of coals are raiſed for home uſe, as well as being ſent coaſtways, and, in ſome caſes, for exportation. They are a ſort of material which is of vaſt importance to the manufacturing ſtate of the county, and which contributes greatly to its proſperity. The quantity is ſo great, when conſidered as a whole, that they would ſeem to be almoſt inexhauſtible.

The cannel coal, which is a ſort that has ſome reſemblance to fine black marble, is principally found and raiſed in the tract about Haigh, near Wigan, which is not more than a few miles ſquare. It lies in pretty thick ſtrata, at the depth of from five to ſeven or eight yards from the ſurface. It is of a very fine, hard, inflammable quality, being got up by ſharp picks, often with conſiderable labour, and for which there is much demand, for domeſtic uſe, in the neighbourhood.

Coals alſo abound in the neighbouring counties of Cumberland and Northumberland, being found in many parts of the eaſtern mountains, and, with not many exceptions, all along the tract, which extends in different degrees of breadth, from Sebergham to Whitehaven, and along the coaſt to Maryport, forming and comprehending a diſtrict of about one hundred ſquare miles, in the former. And they are met with in great plenty throughout the greateſt part of the latter county, particularly in the lower diſtrict of it; being of the beſt quality, and the moſt numerous, and thickeſt ſeams, in the ſouth-eaſt quarter; whence thoſe vaſt quantities are exported which ſupply the great conſumption of the London market, as well as the coaſting and foreign trade. A trade which is the foundation of the commerce of the country, and the principal ſource of its wealth, as well as a never failing nurſery for ſome of the beſt ſeamen of the Britiſh navy. The former county has likewiſe works which ſupply prodigious quantities, both for home conſumption and the coaſtways and export trade. Cannel coal is alſo raiſed in this diſtrict in pretty large ſupplies in the neighbourhoods of Caldbeck and Bolton.

Large portions of this article are likewiſe raiſed from the works in the county of Durham, which in ſome parts are carried on with much ſpirit and enterprize.

Coals are found, and raiſed in full ſupplies, in many places, in moſt of the counties of Scotland, ſo far as Perthſhire; but they have not been met with any farther towards the north in any ſufficient quantities. Where they exiſt, to any extent, in theſe ſituations, they are generally of good kinds, and capable of being got up without any great difficulty, ſeldom lying at any very great depth below the ſurface.

It has been contended by ſome, that the coals in the pits and other places, in this country, are inexhauſtible, while others maintain the contrary to be the caſe; as the matter relates to the county of Northumberland, we have the following calculations, on the authority of the writers of the Agricultural Report of that diſtrict. And they may perhaps equally apply to others. It is ſuppoſed, that towards elucidating this point, it may be of ſome uſe to eſtimate what number of acres are wrought yearly in the county to ſupply the neceſſary conſumption. In order to accompliſh this object, the thickneſs and number of workable ſeams of coal muſt be firſt aſcertained; for which purpoſe they have been favoured with ſections, exhibiting the thickneſs and depth of the various ſtrata, in ſome of the deepeſt pits in the county, one of which has a depth of two hundred and ſeven yards, with ſixteen ſeams of coals; the other a depth of two hundred and forty yards, with fifteen ſeams; conſequently, if the medium be taken betwixt the two, it will be nearly ſix yards thick of workable coal; from which may be formed, it is thought, a calculation of the quantity of coal in an acre of ground, ſuppoſing the aggregate thickneſs of the various ſeams amount to ſix yards.

An acre of ground contains - 4840 ſquare yards,
which, multiplied by the thickneſs 6 yards,

gives - - - 29040 cubic yards in
From which deduct ⅓d for waſte and the parts or pillars neceſſary to be left in working - - } 9680

there remains 19360 cubic yards to be wrought.

And as three cubic yards of coal, when wrought, afford a Newcaſtle chaldron, therefore

19360 = gives 6453 Newcaſtle chaldrons *per* acre,
divided by 3

The coals exported yearly from the rivers Tyne and Wear, with Hartley and Blyth, amount to about 825,000 chaldrons, which, with the home-conſumption of the two counties of Northumberland and Durham, will make the quantity of coals raiſed yearly about 1,000,000 chaldrons.

And the chaldrons raiſed yearly } 1,000,000 = gives 155 acres nearly *per* year, cleared of coal ſix yards thick.
divided by the chaldrons *per* acre } 6453

And by eſtimating the breadth occupied by the caking coals to be on the average eight miles broad, and twenty-five miles long in the two counties, it is found that there will be about two hundred ſquare miles, or 128,000 acres of coal proper for exportation.

From Newcaſtle 510,000 chaldrons.
—— Sunderland 315,000 ditto.

In all 825,000

Then the whole area 128,000 = 825 years. The time before this ſpace will be wrought out.
divided by the yearly conſumption - } 155

It is, however, ſuggeſted, that there are ſome reaſons to ſuppoſe that a thickneſs of ſeam equal to ſix yards will not be obtained all over an extent of two hundred ſquare miles, probably not more, on an average, than four yards; in which caſe the coal will be exhauſted in five hundred and fifty years. And if the aggregate thickneſs of the ſeams to be obtained ſhould prove only three yards, then little more than four hundred will be the term of continuance; but it is probable, it is thought, that before the half of that time be elapſed, the price to the conſumer will be conſiderably increaſed from the increaſed expence of obtaining them, and the increaſed length of carriage from the pits to the rivers; this laſt, it is preſumed, may be reduced in ſome ſituations, by adopting canals inſtead of waggon-ways, which, it has often been wondered at, have never yet been attempted. From this inveſtigation, it is ſuggeſted, that the apprehenſions of exhauſtion are not ſo chimerical as they have been ſuppoſed and repreſented to be by ſome perſons. When, however, the vaſt extent of the working and unwrought tracts, in the different parts of the country, are conſidered, there cannot be any grounds for fear, in this reſpect, for a vaſt length of time yet to come.

Pits, ſome what of the quarry kind, are wrought in one diſtrict of this country, that of Cheſhire, for the raiſing of rock ſalt, in ſome of which large quantities of this material are procured, from different depths, and different thickneſſes of the ſtrata of it. In the getting of it different means are employed, as thoſe of blaſting, picking with implements, for the purpoſe of roofing, the uſing of horſes, and machinery wrought by ſteam, for forcing up the ſubſtance, and ſome others. The digging, raiſing, and working of this article, employs a great number of labourers, and it is of much importance to the county in many points of view.

But though this ſort of material is found in ſeveral different parts of the county, pits, or ſhafts of it, are at this time only wrought in the vicinity of the town of Northwich. This ariſes from a great many different cauſes, but principally from that of the want of water-carriage for the conveyance of the material from them. The number of pits or ſhafts, which there are at this time in work, for the purpoſe of raiſing this article, are about a dozen. They are by much the moſt commonly made in ſomething of the ſquare form, being ſecured on the ſides by means of ſtrong timber, but they have occaſionally a round form, and are walled on the ſides with bricks.

The beds of this material, that are to be raiſed, are wrought at various depths, the deepeſt being in general the moſt pure, and they vary equally in their thickneſs and directions, as ſuggeſted above. In ſome caſes the beds are of the greateſt thickneſs, the more they approach the north-eaſt, decreaſing in a gradual manner, in their courſe to the ſouth-weſt; and in ſome inſtances they incline from north-weſt to ſouth-eaſt, dipping at the rate of about three feet in twenty-ſeven or thirty.

The ſtrata, which are paſſed through in getting at and working the rock-ſalt, lie in a very regular manner, and conſiſt, in general, of a hard clayey ſubſtance and a ſort of gypſeous material in mixture in various ways and proportions, that of the latter kind being the moſt predominant as the pit or ſhaft approaches the rocky ſaline ſubſtance. In working, the clayey matter is deſignated by the name of *metal* of the ſeveral different colours belonging to that ſort of ſubſtance, and the other material by that of *plaiſter*. Theſe ſtrata are moſtly of a ſolid compact nature, but occaſionally broken in particular places, when the metal is termed *ſhaggy* by the workmen.

In the buſineſs of working the pits, and raiſing the rock-ſalt, the rocky beds are reduced into pieces of proper ſizes for the purpoſe, by means of blowing them with gunpowder, and thoſe of ſplitting and dividing them with hammers and proper wedges for ſuch uſes; a good ſecure headway or roofing being conſtantly provided in the firſt place, to the opening from which the ſalt-rock is to be taken, which is effected by the uſe of ſmall ſharp picks, carrying on the work in a plain ſimple chambering manner.

The workings are ſunk from theſe chamberings to different depths, as the nature of the beds of rock, and the quantity of the purer kind of rock-ſalt, or Pruſſian rock, as the workmen term it, may direct; but commonly about fifteen feet. Occaſionally the roofs or headways of the pits or ſhafts are ſupported by conſiderable ſquare pillars diſpoſed in a ſomewhat regular manner, but in other caſes they are wrought out in a ſort of long openings, according as the workmen are inclined.

In getting the rock-ſalt, the workmen are paid by the ton at the rate uſually of about two ſhillings, they finding the gunpowder and other tools.

In raiſing the ſalt from the pits or ſhafts, horſes were formerly entirely made uſe of, but within theſe few years, recourſe has been had to the improved ſteam-engine, as already noticed, though it is not yet generally employed at every pit. See Rock-salt, Rock-salt *Pits*, Salt, and Salt *Brine Springs*.

It is evident from the above account, that in whatever way they are conſidered, the quarries of different kinds in this country are of very material importance to its

profperity and convenience; contributing largely to the carrying on of different forts of works and improvements. Without them much ufeful labour muft be wholly at a ftand; a variety of neceffary bufineffes be incapable of being carried on; and the effects of it upon various arts and manufactures, be much too ferious to be thought upon. In fhort, the numerous fubftances of different kinds, which are taken from the bowels of the earth in this country, conftitute one great fource of our national wealth and profperity.

Quarries, *Pits*, &c. *Draining of*, the proper, moft convenient, and appropriate means of rendering all fuch forts of works dry, free from water, and in a fit ftate to be wrought with eafe and advantage. In the effectual performance of all kinds of undertakings of this nature, there is occafion for the application of the fame principles, which are fpoken of and explained in confidering the nature of draining land in general, and the particular manner which is neceffary to be purfued in the practice of fpring draining. See Draining *of Land*, and Spring-*Draining*.

There can be no doubt, indeed, but that the having recourfe to fuch principles, and the modes of practice refulting from them, will be equally expeditious, beneficial, and fuccefsful, as well as in many fituations of very material importance, in the various cafes of this fort, as in thofe which have been mentioned; by leading to and introducing the moft ready and eafy means of diminifhing the quantities of water, which are frequently met with in the courfe of working them, and which not unfrequently obftruct and hinder in a very high degree, but fometimes wholly put a ftop to the work which is carrying on in them. Such, at leaft, is very often the cafe in quarries of the free-ftone, lime-ftone, flag-ftone, marle, and other kinds, as well as in pits of the coal and other forts. The want of this fort of knowledge, of courfe, is one great caufe why fuch a number of quarries and works of that kind, in different parts, often lie altogether, or for a great length of time, in an unwrought ftate; which might otherwife be wrought to very great advantage.

As it is now well underftood, that moft fprings and fubterraneous collections of water are formed and fupplied from fuch grounds or lands as lie higher than that of the places where they are found or met with, which, on account of their being of an open or porous nature, admit that of rain and other forts of moifture to filtrate and pafs freely through them, which finking and defcending to very great depths, through fuch open materials of the rocky, fandy, gravelly, and other loofe qualities, before it becomes impeded and obftructed by fome fort of impenetrable ftratum or layer of an earthy or folid ftony nature, fuch for inftance as thofe of pure ftiff clay or compact rock; it may happen, that in many fuch cafes, in finking pits or fhafts for ftone, coal, or any other kind of fubterraneous material near the bottoms of hills or high grounds, beds of quickfand will be met with, and dug into, which are fo full of water, that to pafs through them becomes a moft troublefome, difficult, and expenfive piece of work, and fometimes impoffible to be performed, but which, from knowing that the water proceeds from the porous ground that lies above, it may often be practicable to intercept and cut off the greater part of the water, before it reaches fuch fand beds in the quarries, pits, and fhafts, by the means of boring into and tapping the water at the *tail* of the banks of this nature, provided that the ground naturally declines lower than the place where the fand is found in the quarries, pits, &c., and the whole or moft of the water be drawn off, and diverted from them at a comparatively trifling expence to that which is employed as the common remedy in fuch cafes and circumftances.

In order to accomplifh this intention, it will be neceffary, in afcending from the quarry or pit, to carefully examine and afcertain, if at any place higher on the declivity, any porous ftratum, bed of rock, fand, or gravel, *tails* out, which may conduct and convey the water contained in it to the fand bed, which is below in the works; and where any fuch bed is found, to cut or bore into it in fuch a manner as to form a drain, that is capable of carrying away the whole or the greateft part of the water, and of courfe to clear, or diminifh the quantity contained in the quarry or pit, which would otherwife have continued to defcend through fuch porous fubftrata or beds, and have continued to fill the fands, or quarries and pits.

But although this part of the bufinefs may have been accomplifhed, and the fupply of water from the higher ground entirely cut off, a fufficient quantity to injure, hinder, and inconvenience the working of the quarries or pits, may yet continue to drain and ooze from the fides of the fand beds, notwithftanding they fhould happen to *dip* towards the lower ground, in which cafes, however, that water may readily and with great eafe be commonly drawn off at fome particular point in it.

In order to effect this, and thereby remove the inconvenience of this filtrating water, in defcending from the quarries or pits along the declivity, it fhould be endeavoured to difcover and afcertain, at what particular point or place in the low ground, the fand terminates or *tails* out, which is moftly beft accomplifhed by means of proper levelling; and if there fhould be there any appearance of the waters having a natural outlet, it may, by means of making in it a deep drain, be far more readily and effectually drawn off and removed; as fprings, for the moft part, naturally pafs and flow through narrow, winding, convoluted openings, or perforations; of courfe, whenever the orifices or paffages are opened, enlarged, or made lower than before, the difcharge of water becomes greater and more expeditious. Where, however, there happens to be a deep impervious layer or covering of clay, or other matter of a fimilar nature, placed above or upon the termination or tail of the fand, the drain need only be cut down to it or a little way into it, as by means of boring through it, or the remaining portion of it, a ready and eafy outlet or paffage may be given to the whole of the water, that may be contained in the fand-bed or other porous ftratum.

This mode of draining quarries and pits may often be of great utility, advantage, and convenience, as it will alfo, in a great degree, remove, or at any rate relieve, the trouble and difficulty that would afterwards have attended the finking the quarry, pit, or fhaft; as the water thus drawn or cut off, muft of neceffity diminifh and reduce the quantity, which would have been found at a greater depth, the fame body of it probably paffing downwards from one ftratum to another, as far as they continue to be porous, or capable of admitting it. Therefore, it is of very material importance to drain and lay dry all fuch ground as is fituated higher, but contiguous to quarries, pits, or other deep fubterraneous works of the fame kind, for the above ftated reafons. And it may, in general, be accomplifhed with but little trouble, difficulty, or expence, by adopting the fame principles, and the fame means.

But in regard to the removal of the water found and contained in the bottoms of fuch quarries, pits, or deep works, it muft be drained off and got rid of in quite a different manner, as the level of the ground may probably be, or decline, nowhere lower than the mouths or openings of fuch quarries,

pits, &c.; as it is solely and particularly on the supposition, and in such cases as where the direction of the different strata and sand-beds have a *dipping* position with the natural inclination of the surface of the land, or lie nearly horizontally, that the method of proceeding which is stated above is practicable, or capable of being employed with any sort of advantage. But should they, for instance, lie in a reverse or contrary direction, there is but little possibility or chance of accomplishing the object, the removal of the water, unless by discovering or hitting on their terminations, somewhere on the opposite sides of the hills or elevations, which in some cases may very nearly or exactly be found out, by ascertaining the precise inclination or direction of the materials of the quarries, pits, &c. and by a careful and exact use of the level. But this will be much better comprehended, and a more clear, full, and perfect notion of its nature be afforded, by the section figure in the plate on draining quarries, pits, &c. in agriculture, as given by Mr. Elkington, in his work on that subject.

This is the manner which is to be pursued in preventing the effects of water, or cutting off that which is met with in sinking the quarries, pits, shafts, or other similar works, before reaching or arriving at the stone, coal, or other sort of material that may be wanted; but that which is found in the bottoms of these different kinds of undertakings, or which proceeds from the rocks or their sides, or in other ways, in the course of working them, is commonly got quit of by means of some sort of machinery, as that of the engine or other kind of pump, in order to assist in working of which, the water gained by cutting the drains already noticed may be particularly useful, especially where the usual stream for that purpose is insufficient in saving the great expence of working such machinery by the power of steam. But without the aid of a natural stream, which is capable of being converted to this purpose, it is rarely possible to find, by means of drains, or in any other way, a quantity of water sufficient to drive such weighty machinery, in a situation of proper height, to have the full and necessary command of it. However, in many cases it may be an acquisition of great utility and value. It is explained at *fig.* 2. in the same plate.

In some situations, where a full and proper command of water can be had, and where the entrance to the quarry, pit, shaft, &c. is also suitable for the purpose, the use to which it may be converted and applied is still more important and advantageous, as the driving of machinery for bringing out the various kinds of materials, and at the same time working an engine-pump, in order to clear the works of the subterraneous water which flows from the cavities of the rocks, which are met with in working these sorts of pits, &c.

It has been remarked in Mr. Elkington's work on draining, in these cases, that the duke of Buccleugh's coal-works, near Langholm, in the county of Dumfries, afford a striking example of this, as well as of the superior powers of water and machinery, when properly combined, where a command of the former can be had, and when the latter is constructed on proper principles, and conducted with that care and ingenuity which are requisite in such difficult undertakings.

In working quarries of lime-stone, free-stone, and other sorts of materials, it not unfrequently happens, that, at a certain depth, part of the rock or other body, which contains the water, is hit upon, by which they are soon so filled with it, as completely to put a stop to the work proceeding any deeper, where the best and often the greatest part of the stone is situated. In all such cases, the most usual remedies have been, either the erection of a wind-mill pump, to draw out part of the water, as the whole cannot be taken away by such means, or the opening of a new quarry or pit contiguous to the other, which at the same depth mostly meets with a similar obstruction, or the bringing up of a very deep cut, often at great expence, under the level of the water, from the nearest declivity or hollow that can be met with. However, by the following method, all quarries of lime-stone, free-stone, marle, or other materials of the same nature, which are liable to such sort of obstruction, may be completely and effectually cleared of the water at but little expence; while, at the same time, the drain which is made may serve the double purpose of that, and the laying of the wet ground, caused by the spring contained in the rock, which is found contiguous to it, dry.

There commonly lies, immediately under the rock, a bed of strong, stiff, retentive clay, which upholds all the water received and retained by that rocky stratum, and which being, at the same time, bound round on each side by a covering of the same sort of clayey material, or other stiff earthy substance, is not able to discharge itself, and of course constantly remains or stands full in the rock, so as to prevent the working or taking out the stone from the bottom.

In such cases it is necessary, in the first place, to endeavour to find to what side the rock *dips* or inclines, which, in general, may easily be ascertained by the appearance of the surface, in examining the surrounding ground, and the aid of a proper level. When this has been discovered and fully ascertained, a suitable drain must be cut through the clayey covering to the rock, by which the water will be drawn off, which, for want of a proper outlet, formerly stood pent up in the hollows and cavities of the stony stratum or body. This is further and more fully explained by *figs.* 3 and 4, in the same plate.

But, in some cases, this sort of evil or inconvenience may be removed and remedied in a different way. As it frequently happens that a bed or body of the same stone, which has a close, compact nature or quality, is found lying under one which has a more open porous texture, with fissures and cracks in it, that are admissible of water, which obstructs and keeps up the water in the upper bed or layer, in such a manner, that not any of it can pass or filtrate through it to an inferior, or still deeper open stratum or bed; and on sinking or cutting through this compact bed of stone, another layer is met with, which is of so open and porous a nature, as to admit the reception of any water from the above one, which may come upon it.

And sometimes a bed of gravel or sand is found under that of the close stone, which being still more capable of absorbing or taking up any water that may be let down to it, is far better and more properly suited for the purpose of clearing the upper bed of stone from water, than a stratum of open stone itself.

Therefore, when this is discovered and ascertained to be the case, and the water is *kept up* by the second bed of stone, so as to be injurious and hurtful to the working of the upper bed, and which will be equally so in working the second; the work may be greatly freed and relieved by boring through the close bed of stone, and letting down the water into the more porous one below, or into a stratum or body of dry sand or gravel, should there be such a one underneath it. But in place of boring, the sinking of small pits through the close stone is a more effectual method of letting down the water, though a much more difficult one in the execution.

The methods of digging and boring, even in the bottoms of quarries, pits, and shafts, where pumps and other machinery of the same nature are made use of, as has been noticed above, may, in some cases, not only be practicable, but advantageous for letting down the water which they contain into an inferior open stratum.

That of boring has been practised with complete success in the case of a colliery in the county of York, which had been wrought many years, and in which the water was raised about sixty yards by a steam-engine: the proprietors of which, on boring down from the bottom of the pit next to the engine-pit, to the further depth of about ten yards, in order to ascertain the depth or thickness of a seam of coals, which was supposed to lie below those then wrought; the workmen, on taking out the boring rods, found that the water from the works, which usually ran across the bottom of this pit to the engine-pump, now ran down the holes they had made. And that the steam-engine pump, on being set to work, contained little or no water, it having escaped through these holes, and continued to run through the same ever afterwards, rendering the pump useless. It is remarked, that this instance of water at so great a depth from the surface, finding a passage at a further depth of ten yards, or less, and immediately below, is extremely singular and striking in its nature. The situation was much higher than the nearest contiguous vallies, or the level of the sea. Trials of this sort can seldom be made, therefore the cases are rare, uncommon, and curious. But in extensive tracts of level land, where lakes or morasses have been formed, and which cannot be laid dry by cutting open drains, or driving levels through rocks, except at an expence for which the lands, when drained, would never compensate, the above instances warrant the trial of experiments with boring rods, which, if not attended with success, can be made at little expence.

In the county of Lancaster, about the town of Ormskirk, as well as in some other parts, stone quarries are cleared of water exactly in the manner which has been already pointed out, but which *fig.* 5. in the plate will explain much better.

The success of the practice has likewise been farther shewn by the late T. Ecclesston, esq. of Scarrisbrick-hall, an ingenious and extensive proprietor of land in the same neighbourhood, who remarks, that in stone quarries thereabouts, wells or pits are occasionally sunk to the open bed, which have proved serviceable. This mode was practised in a stone delf near the above town in a very beneficial manner. But in order to lay the delf more effectually dry to a greater depth, Mr. Elkington, on viewing the surrounding ground, marked out where he thought the rock terminated, or tailed out, and at the lowest level set out a drain to be cut and carried up to the rock, part of which work has been executed, and a very considerable flow of water comes from it; but on account of its great depth, sixteen feet, the whole will not be finished before he has seen the work again. The drain he has thus laid out is about ten feet lower than the bottom of the stone quarry, and when completed, will lay the head or body of stone dry lower than the present floor. All rocks, for the most part, where they terminate, are succeeded by broken loose stones of the same nature as the rock, and they are frequently, nay almost always, succeeded by sand, which, when in a thick bed, and of a running nature, such as quicksand, often cause great expence in cutting through to the tail end of any rock. This is more fully explained in speaking of the manner of draining in hilly lands, and where the soils are of a mixed nature. See Spring-*Draining*.

Therefore, in all such cases as this, where there is any danger of meeting a quicksand, boring or sinking pits through the bed of close stone, is by much the most adviseable, and at the same time the least expensive method that can be pursued.

The situations of marle pits are for the most part such, that they require very extensive cuts to be made through some parts of the surrounding banks or sides of them, in order to carry or convey off the superabundant quantity of water which prevents their being dug or wrought to advantage. This business might frequently be effected in a much less troublesome and expensive manner, by the method of letting the water down by means of sinking pits or openings through the retaining and upholding stratum underneath the bed of marle, into some absorbent porous body of materials lying still deeper, which is capable of receiving it. Where the space of ground that is occupied by the marle is of considerable size, several pits will be required, in order to effectually carry off the water; and where it is necessary that they should be so deep as to be in danger of falling in, they ought to be walled round the sides, or filled up to near the top with loose stones, through which the water can settle and find its way. And any such cross drains or cuts as may be necessary for the purpose of collecting the water must be so formed and conducted as to lead into the pits. But in many cases the water may be removed and got rid of in a still more easy manner, especially where the situation of the ground is favourable and suited to the purpose. In instances where the surrounding banks decline or fall on the opposite sides *lower than the water*, by cutting drains into them, and boring with an horizontal auger into the tails of the strata containing the water, it may be drawn off and brought down to a level lower than that of the bed or body of marle. And as this water is not unfrequently supplied by a spring which rises in some part of the higher ground, and descends into the place where the marle is found, it will be necessary, in all such cases, to cut off the source of it, and divert the flow of water into some other channel; as by that means the quantity of water below will be lessened, and more easily and readily carried off by the pits or drains which may have been formed.

Mines and shafts, for the purpose of raising different sorts of metals, are often much impeded, or wholly prevented from being wrought by the water which is brought into them from a distance, by various kinds of mineral strata. In many such cases, the water flowing in this way may be intercepted, by making cuts up to the lowest banks of them, from some neighbouring water-course, or other convenient outlet, and then boring or digging pits in the bottoms of such cuts, when the metals to such depths or levels will be rendered free from water, and capable of being wrought. This will, however, be more amply shewn in considering the manner of draining, in some cases of wetness, caused by springs arising in this way. See Spring-*Draining*.

In removing the water, or freeing the bottoms of quarries and pits from it, where machinery is required, the writer of the work on "Landed Property" has remarked, that in cases where *shaft-drains* are found to be impracticable, *well-drains* and pumps become necessary, and are the most proper; as they may be wrought by water, where streams can be conducted to them; or by wind in high exposed situations; or in works of consequence, where fuel is moderately cheap, by small steam-engines. However, in instances where large bodies of water are required to be raised and discharged at the height of a few feet only, marsh-mills, such as are made use of in low marsh-land districts, are found the readiest and most useful kind of machinery for the purpose.

In some cases of this nature, the bottoms of quarries, pits, and mines, may be cleared from water, simply by forming openings into them from some parts of the neighbouring ground where it falls lower than the levels of them, at sufficiently short distances, without any other more expensive works being undertaken for the purpose. This should always be fully considered before any means are resorted to

for laying them dry, as it may occasionally be the saving of much labour, trouble, and money.

QUARRY, in *Glaziery*, a pane, or piece of glass, cut in a lozenge, or diamond-form.

The word seems formed by corruption, from *quarrel*, (which see); unless we will suppose it to come immediately from the French *quarre*, *square*.

Quarries, or quarrels of glass, are of two kinds; *viz.* square and long, each of which is of different sizes, expressed by the number of pieces which make a foot of glass; *viz.* 8ths, 10ths, 12ths, 15ths, 18ths, and 20ths; but all the sizes are cut to the same angle, the acute angle being 77° 19′ in the square quarries, and 67° 22′ in the long ones.

QUARRY, in *Falconry*, is the game, or fowl, which the hawk is in pursuit of, or has killed.

QUARRY, among *Hunters*, is sometimes used for part of the viscera of the beast taken; given by way of reward to the hounds.

QUARRY-*Cart*, a name commonly given to that sort of cart which is principally employed in the work of quarries, and which is generally of a low, compact, strong kind, in its nature, form, and manner of construction, in order to sustain heavy weights, and receive them without difficulty, or the danger of being destroyed. Carts for this purpose should always be made of well-seasoned wood, be well put together, and have sufficient strength of timber in those parts where the main stress of the load is placed. See CART.

Some quarry counties have well-formed carts of this nature, as many of those towards the northern boundaries of the kingdom.

QUARRY-*Waggon*, or *Truck*, a small carriage of the low truck kind, which is much employed in the business of quarries, especially those of the slate kinds, for the purpose of holding and conveying the rough materials, which have been blown from the large massy rocks, or separated in other ways, out of or from the quarries and pits in which they are situated and contained, to the places where they are to receive their different preparations and shapes.

It is formed and constructed on a frame somewhat similar to that of the common barrow, and mounted on two low light iron wheels on the fore part, having two feet behind, projecting from the frame, bent something in the manner of the letter S, and of sufficient length to let it stand or rest in a horizontal position while it is in the act of being loaded. These feet are usually made of iron, but they may be formed of other materials. A sort of inclined plain is formed from the bottoms of the quarries or pits, up which it is forced, with great ease and facility, by the workmen, or small animals of the horse kind, after being filled with these sorts of heavy materials. It is a very useful and convenient machine in this application, being met with in most of the slate quarries in the northern part of Lancashire, as well as in those of many other districts of the kingdom.

QUARRYING, the business of directing and conducting the nature and management of sinking the different kinds of quarries, pits, and shafts, as well as of the different sorts of work which are necessary to be undertaken, carried on, and performed, in the several different descriptions of them; such as those of separating, getting up, and preparing the various sorts of materials for use in the arts, or in other ways. It is a practice which requires considerable knowledge and experience, to be fully master of it in all its different bearings and intentions. See QUARRY, and QUARRYING *Slates and Stones*.

Almost every sort of quarrying-work requires a different kind of management, not only in the opening and sinking the quarries and pits in the grounds at first, but afterwards in the methods and practices of working them, and getting up the various sorts of materials from them, as well as in the modes of preparing, trimming, and arranging them, after they have been raised. They are, however, mostly well known and familiar to the quarry-men and pit-men who are usually engaged in works of the several different kinds.

QUARRYING *Slates and Stones*, the methods of preparing and fitting them for their different uses and applications at the quarries and pits where they have been raised. The former of these articles, particularly those of the blue, green, and purple or blackish kinds, undergo several different sorts of preparation in the quarrying, according to the purposes to which they are to be afterwards applied. They are separated and divided into very thin pieces or slates, where light, neat coverings are required, or in much demand; but for more strong and heavy coverings, in exposed situations, or other places, they are split into much thicker sheets, layers, or slates, and are, of course, more clumsy in their appearance.

Each sort in the business of quarrying is wrought in a separate manner, and packed up by itself; the different sorts having appropriate names, as has been already seen.

The white or brown slates are never divided and prepared in so fine a way as the other kinds, but separated into much thicker flakes or laminæ, in this intention. The blue, green, and purple or darkish sorts, are, for the most part, found capable of being split into very thin laminæ or sheets; but those of the white, or brownish free-stone kinds, can seldom be separated or divided in any very thin manner, as the layers of the large masses of the stones are of a much thicker nature, they consequently form heavy, strong, thick coverings, proper for buildings in exposed climates and situations, and of the more rough kinds, such as barns, stables, and other sorts of out-houses.

In the different operations and processes of this sort of quarrying, slate knives, axes, bars, and wedges are chiefly made use of in the different intentions of splitting and cleaning the slates, they being separated into proper thicknesses by the axe, bar, and wedge, and afterwards chipped into their proper forms and shapes by the knife. All the different inequalities which may appear upon any part of them, are likewise removed by this last sort of implement.

In the quarrying of the latter sorts of materials, or those of stones, the work is usually performed in such a manner as to suit the different uses for which they are intended. Where flags are to be formed, they are split or riven into suitable thicknesses, and squared to different sizes, so as to be adapted to different applications. These operations are executed in rather a rough way, as they are afterwards to be finished by the stone-mason. When for steps, they have the proper breadths and depths given to them in a sort of squaring manner, being left to be completed as they may be wanted for particular uses and applications. Gate-posts are, for the most part, quarried so as to have from about a foot to a foot and a half or more in the square. Trough-stones have the quarrying performed so as to be formed into various proper-sized squares or other forms, in a rough manner, being left in these states to be afterwards hewn and hollowed out, in the intended parts, by the stone-masons.

Stones for building purposes are usually raised and quarried out roughly into something of the square shape, being left in that state for the builders, who afterwards fit them so as to suit their own purposes and intentions.

In the quarrying of stones, the quarrymen commonly make use of large hammers, with cutting ends on one side, the other being formed in a plain manner; strong, sharp, crow-

bars, and broad, ſharp, iron wedges; by which means theſe matters are, from the conſtant practice of the men, ſplit and torn into ſuch forms as are wanted with great eaſe and facility. See QUARRY.

QUARRYING *Tools*, the different ſorts of implements which are employed or made uſe of in the different works of this kind, as in the raiſing and preparing the various ſorts of materials of this nature. They are principally ſuch as thoſe which have been noticed already, and different deſcriptions of picks, mattocks, and jumpers, or boring implements, for the purpoſe of blaſting the various kinds of ſtone, and other hard materials. Theſe tools are individually deſcribed under their particular heads. See each of them.

QUARRYINGS, the ſmall pieces which are broken or chipped off from the different ſorts of materials which are found and wrought in quarries, while they are undergoing their different preparations for various uſes. Theſe ſubſtances, where they are of the hard kind, ſuch as thoſe of the blue and lime-ſtone, as well as ſome other ſorts, are extremely well calculated for the purpoſe of forming and repairing roads, as they are nearly, if not quite, in a ſtate fit for immediate application in this way. Materials of theſe kinds ought, therefore, where they can be conveniently had, never to be neglected by thoſe who have the care and management of roads, as they will ſave much expence and trouble, in a great number of inſtances. See ROADS.

Quartation

QUARTATION, in *Metallurgy*, is the ſeparation of ſilver from gold by means of aqua fortis or nitric acid; which is an operation that has ſomething ſingular in it.

If ſilver and gold are mixed together into a maſs, and the gold is not leſs than one-third part of the maſs in weight, the beſt aqua fortis poured upon it is not at all capable of diſſolving the ſilver; but if you add more ſilver to this maſs, by melting it again in the fire, with ſuch a neceſſary addition of that metal alone as ſhould bring the gold in the maſs to the proportion of leſs than one-third of the whole, and ſuffer it to cool, then aqua fortis poured on it will corrode the ſilver from it: this is alſo by ſo much the more ſtrongly performed, as the quantity of gold is leſs than in the proportion of one-third of the whole maſs; but experience has taught us, that aqua fortis diſſolves ſilver mixed with gold quickly enough when the gold conſtitutes but one, and the ſilver three parts of a mixed maſs of them; and in this caſe, if the ſolution is not too impetuouſly performed, the gold uſually remains in ſuch a proportion, in the ſame figure that the whole maſs had before the ſeparation of the ſilver by this menſtruum; ſo that, in this caſe, there is no reaſon to apprehend the gold's being torn into minute particles, and diſſipated in ſome meaſure; though this can hardly be prevented when the ſilver exceeds the three-quarter proportion, in regard to the gold in the maſs. The artificers, therefore, always make it their ſtudy to obſerve very exactly this proportion of the gold being one-fourth part of the mixture; and thence it is that the operation itſelf has been called quartation.

In order to aſcertain nearly the proportion of gold and ſilver in a maſs, the aſſayers rub this maſs upon a touchſtone, ſo as to leave a mark upon it; and they then make marks upon the ſtone with ſome of thoſe needles, called touch-needles, the colour of which they think comes neareſt to that of the maſs: by comparing the marks of theſe needles with the mark of the maſs, they diſcover nearly the proportion of the gold and ſilver in the maſs. The maſs of gold and ſilver to be quartered ought previouſly to be granulated, by melting it in a crucible, and pouring it into a large veſſel full of cold water, while at the ſame time a rapid circular motion is given to the water by quickly ſtirring it round with a ſtick or broom. The veſſels generally uſed for this operation are called parting-glaſſes. The aqua fortis muſt be purified for this purpoſe, and ſhould be ſo ſtrong as to be capable of acting ſenſibly on ſilver when cold, but not ſo ſtrong as to act violently. If it be very ſtrong, and the veſſels

well closed, a small quantity of the gold will be dissolved along with the silver, which is to be guarded against. Little heat ought to be applied at the beginning, the liquor being apt to swell and rise over the vessel; but when the acid is nearly saturated, the heat may be safely increased. When the solution ceases, which may be known by the discontinuance of the effervescence, or emission of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis must be added, that all the silver may be dissolved. If the operation has been performed slowly, the remaining gold will have still the form of distinct masses, which are to receive solidity and colour by putting them into a test under a muffle, and making them red-hot. If the operation has been performed hastily, the gold will have the appearance of a black mud or powder, which after five or six washings with pure water, must be melted. The silver is usually recovered by precipitating it from the aqua fortis by means of copper vessels, into which the liquor is poured, or of plates of copper, which are thrown along with the liquor into glass vessels. A considerable heat is required to accelerate this precipitation. Dr. Lewis observes, that when the aqua fortis has been perfectly saturated with silver, no precipitation is occasioned by plates of copper, till a drop or two of aqua fortis is added to the liquor, and then the precipitation begins, and continues as usual. The precipitated silver must be well washed in boiling water, and fused with some nitre, the use of which is to scorify any cupreous particles which may adhere to the silver.

Here we may add, that silver and gold may be parted from one another by the vitriolic acid, as effectually, though not so commodiously, as by the nitrous. If the compound be reduced into grains or thin plates, and boiled in about twice its weight of oil of vitriol to dryness, the silver will be so far corroded, as to be easily washed off by a little more of the acid: or if the mass, after the corrosion, be melted in a crucible, the gold will separate and subside, the silver forming a scoria above it. Gold may be purified in the same manner from several other metallic bodies. M. Scheffer says, that this is the most direct way of separating tin from gold. Lewis's Com. Phil. Techn. 95. 149, &c. See Assaying, Depart, and Gold.

Quick lime

QUICK *Lime*, in *Rural Economy*, ſuch lime as is in the cauſtic or moſt active ſtate, and which poſſeſſes the greateſt power of operating upon different ſubſtances with which it may come in contact. It is quite the oppoſite in its qualities and properties, to that which has fallen down into a powdery ſtate, in conſequence of being ſaturated with water and carbonic acid gas, or fixed air, or which is ſlaked and become effete. Its powers, when applied upon land in this condition, have already been noticed in ſpeaking of lime. See LIME.

But it poſſeſſes qualities and properties in the way of a cement, the utility of which for building, for various domeſtic purpoſes, properly belong to this place. According to Dr. Anderſon, lime is in the beſt and moſt fit ſtate for this uſe when the moſt perfectly cauſtic, or in the moſt cryſtalizing condition. It is remarked, that the powder of lime, when reduced by means of water into a thin or fluid ſort of paſte-like form, and then ſuffered to become dry, concretes into a coherent maſs, which fixes to ſtones and other rough bodies in a very firm manner, and in this way becomes a proper cement for building any ſort of walls. And that, after this paſty material has once become firmly dry, it is quite indiſſoluble in water, and incapable of ever being ſoftened again by the moiſture of the atmoſphere or other ſimilar cauſes. Hence it excels many other ſorts of cements.

When compoſed for the purpoſe of building walls, &c. it is uſually denominated *mortar;* but when formed as an application in the way of a ſmooth coating upon any plain ſurface without intermixture with ſtony matters, it is commonly here termed *plaiſter*.

When made from the lime of the purer ſort of lime-ſtone, it is found to be more ſoft and crumbly, and to acquire a leſs degree of hardneſs, and to be broken with much leſs force, than where the lime-ſtone from which it is made contains a large proportion of ſand, in which caſe it becomes much more hard, firm, and durable.

It has, however, been diſcovered that the pureſt lime may be rendered a firm cement by adding a proper proportion of clean hard ſand to it; hence the practice of blending ſand with lime, when intended for mortar, has become ſo univerſal. This is fully ſhewn to have been very early the caſe, by the oldeſt lime-built walls which are now to be met with.

It nevertheleſs ſtill remains a deſideratum to aſcertain the due proportion of ſand which is neceſſary, as both writers and practical maſons greatly diſagree in opinion on this matter, as well in their directions about the mode of mixing the materials, as of applying the cement; ſome of the more modern, eſpecially, aſcribing extraordinary effects to a ſmall variation in theſe particulars, while others deny that theſe circumſtances have any ſenſible effect on the durability and firmneſs of the cement.

It is conceived that theſe different and contradictory opinions ariſe from an imperfect knowledge of the nature of quick-lime, and the variations it may admit of; for theſe variations are ſo very great, as to render it impoſſible to afford any general rules that can poſſibly apply in all caſes. It is, therefore, conceived to behove thoſe who are deſirous of acquiring any conſiſtent and ſatisfactory knowledge on this head, to endeavour to aſcertain, in the firſt place, the circumſtances which render calcareous ſubſtances *at all* capable of becoming a cement, and then to trace the ſeveral changes that may be produced upon it by other extraneous cauſes.

Having explained the circumſtances which cauſe the differences in lime-ſtone, and pointed out the different conſtituent principles of it, as well as various other peculiarities; it is ſtated that lime, which has in any way abſorbed its full quantity of air from the atmoſphere and become mild, is altogether unfit for becoming a cement, and that, of courſe, it is evident, that a great change may be produced upon the quality of any lime, by having allowed leſs or more of it to be in this ſtate before it is worked up into mortar. And further, that if a large quantity of water be put to freſh ſlaked quick-lime, and beat up with it into a thin ſort of paſte, the water diſſolves a ſmall portion of the lime, which as it gradually abſorbs its air, is converted into cryſtals; between the particles of which cryſtals, that part of the lime which was not diſſolved, and the other extraneous matters which may have been mixed with it, are entangled, ſo as to form a firm coherent maſs of the whole. And that the paſty ſubſtance formed in this manner, is the well-known article mortar; and this heterogeneous, imperfectly ſemi-cryſtallized maſs, conſtitutes the common cement employed in building ordinary walls or other erections. Theſe circumſtances, therefore, being known, it is thought that it will not be difficult to comprehend what are the particulars that are neceſſary to form the moſt perfect cement of this nature. That ſince lime becomes a cement only in conſequence of a certain degree of cryſtallization taking place in the whole maſs, it is ſufficiently obvious that the firmneſs and perfection of that cement muſt depend upon the perfection of the cryſtals; and the hardneſs of the matters that are entangled among them; for if the cryſtals are ever ſo perfect and hard of themſelves, if they be ſeparated from one another by any brittle incoherent medium, it is evident that the whole maſs muſt remain in ſome degree brittle and incoherent. That as water can only diſſolve a very ſmall proportion of lime, even when in its moſt perfect ſaline or cauſtic ſtate, or while it remains deprived of its carbonic acid gas, and as happens in other ſimilar caſes, no more of the lime can be reduced to a cryſtalline maſs than has been actually diſſolved in the water; it happens of courſe, that if mortar be made of pure lime and water alone, a very ſmall proportion only can be diſſolved by that ſmall quantity of water that is added to it: and as this ſmall proportion alone can afterwards be cryſtallized, all the remaining undiſſolved particles of the lime will be entangled among the few cryſtals that are formed. And as the undiſſolved lime in this maſs will in time abſorb its air, and be converted into *mild* calcareous earth without having had a ſufficiency of water to allow it to cryſtallize, it muſt concrete into a friable maſs exactly reſembling chalk; it follows, that this kind of mor-

tar, when as dry as it can be made, and in its higheſt degree of perfection, will always be ſoft, and eaſily crumbled into powder.

But that, if, inſtead of forming the mortar of pure lime alone, a large proportion of ſand be added to it, the water will in this caſe diſſolve as much of the lime as in the former; and the particles of hard ſand, like ſticks or threads, when making ſugar-candy or other cryſtals, while ſurrounded by the watery ſolution, will help to forward the cryſtallization, and render it more perfect than it otherwiſe would have been, ſo as firmly to cement the particles of ſand to one another. And as the granules of ſand are perfectly hard of themſelves, ſo as not to admit of being broken down like the particles of chalk, it neceſſarily follows, that the cement made of theſe materials muſt be much more perfect in every reſpect than the former.

After conſidering a variety of circumſtances in regard to the ſolubility of lime in water, and its cryſtallization, it is remarked, that when a large quantity of ſand is mixed in the mortar, that ſand will of courſe bear a great proportion to the whole maſs; ſo that the water that may be mixed with the mortar will be much greater in proportion to the quantity of lime contained in this mortar, than if the whole had conſiſted of pure calcareous matter. And that, as the ſand abſorbs none of that water,—that water, now pure, is at liberty to act once more upon thoſe few particles of cauſtic lime that may ſtill remain in the mortar, which will be diſſolved and converted into cryſtals in their turn. In this way it may happen, in ſome circumſtances, that a very large proportion of the lime may become cryſtallized; ſo that the mortar will conſiſt almoſt entirely of ſand enveloped in cryſtalline matter, and become in due time as hard as ſtone itſelf; whereas mortar, conſiſting of pure lime, without ſand, can hardly ever be much harder than chalk. It is not, however, to be ſuppoſed, that in any caſe this dried mortar will aſſume that tranſparent cryſtalline form, or the compact firmneſs of ſome ſorts of calcareous matters, ſuch as marble and lime-ſtone. In mortar, in ſpite of the utmoſt care that can ever be taken, a very conſiderable quantity of the lime muſt remain undiſſolved; which undiſſolved lime, although it may be ſo much ſeparated by the ſand and cryſtalline lime-ſtone as not much to affect the hardneſs of the mortar, yet it muſt ſtill retain its white chalk-like appearance. As marble and lime-ſtone are, however, always formed by thoſe particles of lime that have been wholly diſſolved in water, and from which they have been gradually ſeparated by a more ſlow and more perfect mode of cryſtallization, they have nothing of that opaque calx-like appearance, but aſſume other colours, and appear more firm, uniform, and compact; the ſand and other matters that may be enveloped in them being entirely ſurrounded with a pure cryſtalline matter.

But to obtain the moſt perfect kind of mortar, it is not, however, enough that a large proportion of ſand ſhould be employed, and that the ſand ſhould be intimately mixed with the lime; it is alſo of the utmoſt importance that a large proportion of water be added; for without this it is impoſſible that a large proportion of the lime can be cryſtallized: and the mortar, in that caſe, would conſiſt only of a mixture of chalky matter and ſand, which could hardly be made to unite at all, and would be little more coherent than ſand by itſelf, and leſs ſo than pure chalk. In that caſe, pure lime alone muſt afford rather a firmer cement than lime with ſand. It is alſo of very great importance that the water be retained as long in the mortar as poſſible: for if it be ſuddenly evaporated, it will not only be prevented from acting a ſecond time upon the lime, after a part of what was firſt diſſolved has been cryſtallized, but even the few cryſtals that would be formed when the water was ſuddenly evaporating, would be of themſelves much more imperfect than they otherwiſe moſt certainly would have been. In proof of which, inſtances of the cryſtallization of common ſalt, lump ſugar, and ſugar-candy, are adduced; after which it is noticed, that every one knows what a difference there is between the firmneſs of the different ſubſtances; and that as great muſt be the difference between the firmneſs of that cement which has been ſlowly dried, and that which has been haſtily hardened by the powerful action of a warm air.

It is contended, that it is owing to this circumſtance that the lime, which remains all winter in a mortar tub filled with water, is always found to be much firmer and more coherent than the mortar that was taken from the ſame tub and uſed in any work of maſonry, although in this caſe the materials were exactly the ſame. From the ſame cauſe, any work cemented with lime under water, if it has been allowed to remain undiſturbed and uninjured until it has once become hard, is always much firmer than that which is above the ſurface of the water.

In order to render the force of the above reaſoning more ſtrong and convincing, lime cement or mortar is compared to a maſs of matter conſiſting of a congeries of ſtones cloſely compacted together, and united by a ſtrong cementing matter that had, while in a fluid ſtate, pervaded all the interſtices between the ſtones, and afterwards become a ſolid indiſſoluble ſubſtance. If the cementing matter be exceedingly hard and coherent, and if the ſtones bedded among it be alſo very hard and firm, the whole maſs will become like a ſolid rock, without fiſſures, that can hardly be broken to pieces by the power of man. But, although the cement ſhould be equally firm, if the ſtone, of which it conſiſts, be of a ſoft and friable nature, ſuppoſe chalk or ſand-ſtone, the whole maſs will never be capable of attaining ſuch a degree of firmneſs as in the former caſe; for when any force is applied to break it in pieces, although the cement ſhould keep its hold, the ſolid matter cemented by it would give way, and the whole would be eaſily broken to pieces. Whereas in mortar, the ſand that is added to it repreſents the ſtones of a ſolid matter in the compoſition, the particles of which are united together by the lime which had been formerly diſſolved, and now cryſtallized, which becomes an exceedingly ſolid and indiſſoluble concretion. And as the particles of ſand are of themſelves exceedingly hard, and the cement by which they are united equally ſo, it is plain that the whole concretion muſt be extremely firm, ſo as to require very great force to diſunite any particle of it from the whole maſs. But if, inſtead of employing ſand, the only ſolid body that is entangled among the cementing matter ſhould be chalk, (as in all caſes where the mortar conſiſts of pure lime alone,) or any other ſlightly cohering ſubſtance, let the cementing particles of that compoſition be ever ſo perfect, it is impoſſible that the whole can ever attain a great degree of firmneſs, as theſe chalky matters will be eaſily broken aſunder.

It is remarked, in addition, that a variety of conjectures have been made about the nature of the lime cement employed by the ancients. It has been thought that they poſſeſſed an art of making mortar, which has been long ſince entirely loſt; as the cement in the walls which have been built by them, appears to be, in many caſes, much firmer than that which had been made in modern times. Yet, when the mortar of theſe old buildings is analyſed, it is found to conſiſt of the ſame materials, and nearly in the ſame proportions, in which they are now made uſe of.

And it is thought probable, that their only ſecret conſiſted in mixing the materials more perfectly than the rapidity or avarice of modern builders will permit, in employing their mortar in a much more fluid ſtate than is done now, and in allowing it to dry more ſlowly, which the immoderate thickneſs of many of their walls would naturally produce, without any preconcerted deſign on their part. Tradition has even handed down to the preſent times the memory of the moſt eſſential of theſe particulars; as the lower claſs of people, in every part of the nation, at this moment invariably ſuppoſe and believe that theſe old walls were compoſed of a mortar ſo very thin, as to admit of its being poured, like a fluid, between the ſtones, after they were laid in the wall: and the appearance of theſe old walls, when taken down, ſeems to favour this popular tradition. Nor is it doubted but that this may have been the caſe. The ſtones in the outer part of the wall, it is thought, were probably bedded in mortar nearly as is practiſed at preſent; and the heart, after being packed well with irregular ſtones, might have the interſtices between them entirely filled up with fluid mortar, which would inſinuate itſelf into every cranny, and in time adhere as firmly as the ſtones themſelves, or even more ſo, if the ſtones were of a ſandy friable nature. And that, as theſe walls were uſually of very great thickneſs, it might often happen, that the water in this mortar, by acting ſucceſſively upon different particles of cauſtic lime, would at length be entirely abſorbed by ſucceſſive cryſtallizations, ſo as to become perfectly dry, without any evaporation at all; in which caſe, a very large proportion of the original lime muſt have been regularly cryſtallized in a ſlow and tolerably perfect manner, ſo as to attain a firmneſs little inferior to lime ſtone or marble itſelf.

It is ſuppoſed that, upon theſe principles it is eaſy to account for the ſuperior hardneſs of ſome old cements, when compared with that of modern times, in which a practice very different is uſually followed, without having recourſe to any wonderful *arcana* whatever.

Monſieur Loriot, a late French writer, imagined that he had made a perfect diſcovery of the way in which the ancients employed their quick-lime, ſo as to obtain ſuch an extraordinary firm cement; from which diſcovery, he conceived, very important benefits might be derived to ſociety. According to his opinion, the ancient cement conſiſted of lime and ſand nearly in the ſame proportions as are commonly employed for that purpoſe at preſent. But inſtead of making it of ſlaked lime entirely, as is done now, he contends that they employed a certain proportion of their lime *unſlaked*, which they mixed with their mortar immediately before it was uſed. And it is further noticed, that this newly diſcovered cement dries and hardens almoſt under the hand of the operator, without cracks or flaws of any ſort; that it neither expands nor contracts with the air;—that it is impervious to moiſture, and may not only be employed for making roofs of houſes that are ſubjected to the continual dropping of water, baſons, aqueducts, canals, &c. which will inſtantly contain water in any quantities but even finer works of the pottery kind; that it perfectly reſiſts froſts, and has a variety of other intereſting qualities. The trials of Dr. Anderſon with the ſame ſort of materials do not, however, confirm the great certainty and utility of this diſcovery. "That ſuch effects as the writer deſcribes," ſays the doctor, "will invariably be produced, merely by adding a certain proportion of unſlaked lime in powder to mortar, or even by making the mortar entirely with powdered quick-lime, I may without heſitation venture to deny, not only from the reaſoning that has been given, but from actual experiment, again and again repeated by myſelf; and which is likewiſe, in ſome meaſure, corroborated by the experience of Mr. Doſſie."

On theſe accounts, it is ſuppoſed, that if Monſieur Loriot, has really experienced theſe uncommon effects from the mortar he has tried, it muſt have been occaſioned by ſome other unobſerved peculiarity, and not merely by the circumſtance to which he ſeems to aſcribe it. Poſſibly the doctor ſuppoſes the lime he employed may have been impregnated with a gypſum, or the ſulphate of lime, as is probable, for many reaſons. The effects and qualities of which, as to becoming a fine powder, and of ſuddenly ſetting, are well known, but it never acquires the ſtony hardneſs that lime cement is ſometimes endowed with, although it takes the ſmootheſt poliſh of any cement we know: on which account, it has long been employed as a plaiſter where fine ornaments are required.

There are unqueſtionably, however, many doubtful and myſterious circumſtances connected with this matter, which require the aid of further trials and experience in their full explanation.

There are ſtill further a few other circumſtances that may influence the quality of common lime-mortar. If lime-ſtone be ſufficiently calcined, it is deprived of all its moiſture, and of all its carbonic acid gas, or fixed air. But experience ſhews, that lime-ſtone will fall to powder on the effuſion of water upon it, when it is much leſs perfectly calcined, and while it ſtill retains almoſt the whole of its fixed air. And that as maſons have hardly any other rule for judging whether lime-ſtone be ſufficiently calcined, except this ſingle circumſtance of its falling to a powder when water is poured upon it, it may thus eaſily be perceived, that the ſame lime may be more or leſs fitted for making good mortar, according to a circumſtance that, in a great meaſure, eludes the obſervation of operative maſons; for if it ſhould happen that all the pieces of lime drawn from a kiln at one time, were juſt ſufficiently calcined to make it fall to a powder with water and no more, that powder would be altogether unfit for making mortar of any kind. This is a caſe that can ſeldom happen: but as there are a great many intermediate degrees between that ſtate and perfect calcination, it muſt often happen that the ſtone will approach nearer to one of theſe extremes at one time than at another; ſo that the mortar may be much more perfect at one time than at another, owing to a variation in this particular.

All thoſe who have written on the ſubject of lime as a cement, have endeavoured to aſcertain what is the due proportion of ſand for making the moſt perfect cement. But a little attention to the matter will ſhew, that all rules, which could be preſcribed as to this particular, muſt be ſo vague and uncertain, as to be of little utility to the practical maſon; as, beſides the variation which may ariſe from a more or leſs perfect degree of calcination as above, it is a certain fact, that ſome kinds of lime-ſtones are much more pure, and contain a much ſmaller proportion of ſand than others do; ſome being found almoſt perfectly pure, while others contain eleven-twelfths of ſand and all the intermediate proportions of it. Therefore it would be abſurd to ſay that pure lime would require as ſmall a proportion of ſand when made into mortar, as that which originally contained in itſelf a much larger proportion of ſand than any writer has ever ventured to propoſe for being put into mortar.

Beſides, there are differences cauſed by the different nature of the calcination in the different ſorts of lime-ſtone, from which it may, upon the whole, be concluded, that

about one-tenth of *pure* lime-ſtone is not enough calcined to admit of being made into mortar; and that of the moſt impure ſorts of lime-ſtone, not above one-fourth part of the lime contained in it is ſo much calcined as to be in a cauſtic ſtate.

The variation that is produced by theſe means in regard to the proportion of ſand that will be required to the lime in the one or the other caſe, is found to be ſo extremely great as hardly to be conceived. It is, however, ſtated, that the beſt mortar that has been ſeen made, was formed of lime which had been found to contain eleven parts of ſand to one of lime: to this there was added between twice and thrice its whole bulk of ſand by meaſure; which may be allowed to have been at leaſt three times its quantity *by weight*. Therefore, ſuppoſing that every particle of that lime had been ſo perfectly calcined as to be in a cauſtic ſtate, there could not be leſs than forty-ſeven parts of ſand to one of lime. As much may, however, be allowed for the uncauſtic part of the lime as is pleaſed, and the calculation made accordingly. But it is hardly poſſible to ſuppoſe that above one-hundredth part of this maſs, independent of the water, conſiſted of pure cauſtic calcareous earth.

On theſe conſiderations it is conceived, that it is impoſſible to preſcribe any determinate proportion of ſand to lime, as that muſt vary according to the nature of the lime and other incidental circumſtances, which would form an infinity of exceptions to any general rule. But it would ſeem that it might be ſafely inferred that the moderns in general rather err in giving too little ſand, than in giving too much. It deſerves, however, to be noticed, that the ſand, when naturally in the lime-ſtone, is more intimately blended with the lime than can poſſibly be ever effected by any mechanical operation; ſo that it would be in vain to hope to make good mortar artificially from pure lime, with ſuch a ſmall proportion of cauſtic calcareous matter as may ſometimes be effected when the lime naturally contains a very large proportion of ſand. But there ſeems to be no doubt, that if a much larger proportion of ſand were employed, and if that were more carefully blended and expeditiouſly worked than is common, the mortar would be much more perfect than is uſual in modern times, as has been proved by actual trials.

Another circumſtance that tends greatly to vary the quality of cement, and to make a greater or ſmaller proportion of ſand neceſſary, is the mode of preparing lime before it is beaten up into mortar. When for plaiſter, it is of great importance to have every particle of the lime-ſtone ſlaked before it is worked up; for, as ſmoothneſs of the ſurface is the moſt material point, if any particles of lime ſhould be beaten up in it, and employed in work before ſufficiently fallen, the water, ſtill continuing to act on them after it was worked up, would infallibly ſlake ſuch particles, which forcibly expanding themſelves, would produce thoſe excreſcences on the ſurface of the plaiſter commonly termed bliſters. Conſequently, in order to obtain a perfect kind of plaiſter that will remain ſmooth on the ſurface and free of bliſters, there is an abſolute neceſſity to allow the lime to lie for a conſiderable time macerating or *ſouring* in water, before it is worked up. And the ſame ſort of proceſs is neceſſary for the lime when intended for uſe as mortar, though not ſo abſolutely. Great care is, however, required in the management in this reſpect; the principal things being the getting of well-burnt lime, and the allowing it to macerate or *ſour* with the water for only a *very ſhort time* before it is uſed; but that which is the beſt burnt will require the maceration of ſome days in the water before it is ſufficiently ſlaked in the whole maſs for this purpoſe. See SOURING *Lime for Mortar and Plaiſter*.

It has been almoſt univerſally admitted, that the hardeſt lime-ſtone affords a lime that will conſolidate into the firmeſt cement; and hence generally concluded, that lime made of chalk, produces a much weaker cement than what is made of marble or lime-ſtone. It would ſeem, however, that if ever this be the caſe, it is only incidentally, and not neceſſarily ſo. As from the nature of calcareous matter, every kind of lime is equally fit for becoming a firm cement, if it be firſt reduced to a proper degree of cauſticity, and has afterwards a due proportion of ſand properly mixed with it, before it be employed in work. Different ſorts of lime, without doubt, differ much from each other in the proportion of ſand they naturally contain, and, of courſe, require very different proportions of ſand to be added to them before they can be made equally perfect as a cement; which is an economical conſideration, of no ſmall moment in ſome caſes, as it may make one ſort of lime a great deal cheaper than another on ſome occaſions, and, of courſe, deſerves the attention of builders in general. See LIME.

The excellencies and defects of other ſubſtances that may be occaſionally mixed with lime in making cement may be juſt noticed. Thoſe commonly uſed as an addition to mortar, beſides ſand of various denominations, are powdered ſand ſtone, brick-duſt, and ſea-ſhells. And for forming plaiſter, where cloſeneſs rather than hardneſs is required, they are lime that has been ſlaked and kept long in a dry place, till it has become nearly effete, powdered chalk or whiting, and gypſum in various proportions; beſides hair and other materials of that nature. But ſome others have been more lately adviſed, ſuch as earthy balls, ſlightly burnt and pounded, powdered and ſifted old mortar rubbiſh, and others of a ſimilar kind. All of which ſubſtances are found objectionable in ſome reſpect or other for this uſe, ſand being the only perfectly ſuitable material that can be eaſily met with; on which account it has been always juſtly preferred. Pure firm cryſtallized ſand is the beſt, but all pure ſands are not equally proper in this intention. See theſe ſubſtances reſpectively. See alſo CEMENT and SAND.

It is ſtated by ſir Humphry Davy, in his work on "Agricultural Chemiſtry," that there are two modes in which lime acts as a cement; in its combination with water, and in its combination with carbonic acid. When quick-lime is rapidly made into a paſte with water, it ſoon loſes its ſoftneſs, and the water and the lime form together a ſolid coherent maſs, which conſiſts of ſeventeen parts of water, to fifty-five parts of lime. When this hydrate of lime, while it is conſolidating, is mixed with red oxyd of iron, alumina, or ſilica, the mixture becomes harder and more coherent than when lime alone is uſed; and it appears that this is owing to a certain degree of chemical attraction between hydrate of lime and theſe bodies; and they render it leſs liable to decompoſe by the action of the carbonic acid in the air, and leſs ſoluble in water. It is thought that the baſis of all cements that are uſed for works which are to be covered with water muſt be formed from hydrate of lime; and that the lime made from impure lime-ſtones anſwers this purpoſe very well. Puzzolana, it is ſaid, is compoſed principally of ſilica, alumina, and oxyd of iron; and it is uſed mixed with lime, to form cements intended to be employed under water. It is ſtated that Mr. Smeaton, in the conſtruction of the Eddyſtone lighthouſe, uſed a cement compoſed of equal parts, by weight, of ſlaked lime and puzzolana. Puzzolana, it is ſaid, is a decompoſed lava. Tarras, which was formerly imported in conſiderable quantities from Holland, is found

to be a mere decompofed bafalt: two parts of flaked lime and one part of tarras form the principal part of the mortar ufed in the great dykes of Holland. It is fuppofed that fubftances which will anfwer all the ends of puzzolana and tarras, are abundant in the Britifh iflands. An excellent red tarras may be procured in any quantities from the Giant's Caufeway, in the north of Ireland: and decompofing bafalt is abundant in many parts of Scotland, and in the northern diftricts of England in which coal is found.

It is obferved that Parker's cement, and cements of the fame kind made at the alum-works of lords Dundas and Mulgrave, are mixtures of calcined, ferruginous, filiceous and aluminous matter, with hydrate of lime.

It is noticed, that the cements which act by combining with carbonic acid, or the common mortars, are made by mixing together flaked lime and fand. Thefe mortars at firft folidify as hydrates, and are flowly converted into carbonate of lime by the action of the carbonic acid of the air. It was found by Mr. Tennant, that a mortar of this kind, in three years and a quarter, had regained fixty-three *per cent.* of the quantity of carbonic acid gas, which conftitutes the definite proportion in carbonate of lime. The hardnefs of the mortar in very old buildings is alfo thought to depend upon the perfect converfion of all its parts into carbonate of lime. The pureft lime-ftones are the beft adapted, it is faid, for making this kind of mortar. The magnefian lime-ftones make excellent water cements, but act with too little energy upon carbonic acid gas to make good common mortar. The Romans, on Pliny's authority, made their beft mortar a year before it was ufed; fo that it was partially combined with carbonic acid gas before it was employed, it is fuppofed.

It is likewife fuggefted, in regard to the cultivation and improvement of land by means of this material, that quicklime in its pure ftate, whether in powder, or diffolved in water, is injurious to plants; grafs in feveral inftances having been killed by watering it with lime-water: but that lime, in its ftate of combination with carbonic acid, is an ufeful ingredient in foils. Calcareous earth is found in the afhes of the greater number of plants; and expofed to the air, lime cannot long continue cauftic, but foon becomes united to carbonic acid. That lime, when combined with about one-third of its weight of water, conftitutes hydrate of lime; and that it becomes carbonate of lime by long expofure to the atmofphere, the place of the water being fupplied by carbonic acid gas. On mixing frefhly burnt or flaked lime with any moift fibrous vegetable matter, a ftrong action occurs between them, and they form a fort of compoft, part of which is commonly foluble in water. In this way, lime renders matter, before comparatively inert, nourifhing; and from charcoal and oxygen, abounding in vegetable matter, it becomes converted into carbonate of lime at the fame time. Mild lime, or powdered calcareous fubftances, have no action in this way on vegetable matter; by their operation they prevent the too quick decompofition of bodies previoufly diffolved, but do not tend to form foluble matters. Confequently it is clear that the operation of quick-lime and mild calcareous fubftances, depend upon wholly different principles. The former, on being applied to land, tends to bring the hard vegetable matter contained in it into more rapid decompofition and folution, as a proper food for plants. The latter only improve the texture of it, or its relation to abforption: it is merely an earthy ingredient. Quick-lime, in becoming mild, has a fimilar action, but while taking on that ftate, prepares foluble out of infoluble matter. On this depends the operation of lime in the preparation for wheat crops, its efficacy in fertilizing peats, and in bringing into cultivation all forts abounding in hard roots, dry fibres, or inert vegetable matter. The queftion, of courfe, whether quick-lime fhould be applied to land or not, depends on the quantity of inert vegetable matter it contains; and that whether mild lime, marle, or powdered lime-ftone, fhould be ufed or not, on the quantity of calcareous matter already in the land. All forts of land are improved by mild lime, and ultimately by quick-lime, which do not effervefce with acids; and the fandy forts more than the clayey kinds. In land deficient in calcareous matter, but containing much *foluble* vegetable manure, the ufe of quick-lime fhould conftantly be avoided, as tending either to decompofe the foluble matters, by uniting to their carbon and oxygen in becoming mild, or to combine with the foluble matters, and form compounds with lefs attraction for water than the pure vegetable fubftance. The fame is the cafe in regard to moft animal manures; but its operation is different in different cafes, according to the nature of the animal matter. On the whole, it fhould however never be employed with animal manures, except when too rich, or for preventing noxious effluvia. It is hurtful in mixture with common dung, and tends to produce infolubility in the extractive matter. It is ufeful in mixture with fimple vegetable barks, &c.

The folution of the queftion about the inutility and difadvantage of magnefian lime, which has lately been found ufeful in fmall quantities on the poorer lands in Leicefterfhire, as from twenty-five to thirty bufhels the acre, and in larger ones, on the rich foils; it is fuppofed to depend upon that fort of lime having a lefs attraction for carbonic acid than the other, in confequence of the portion of that fubftance in it, and thereby remaining longer in the cauftic ftate; and its becoming fooner a carbonate of lime in the rich than in the poor foils. Magnefia, while in the cauftic ftate, is poifonous to certain kinds of plants, and acts fo in the mixture as lime. It may be ufefully applied in large quantities to peat-earths; and to lands injured by too much of this fort of lime, peat-earth will be a proper and effectual remedy, when ufed in a fuitable proportion.

More full information may be met with on this curious and interefting fubject in the firft volume of Anderfon's Effays on Agriculture and Rural Affairs, in Doffie's Memoirs of Agriculture, vol. ii. and in fir Humphry Davy's "Agricultural Chemiftry."

Railway

RAILWAY, *Tram* or *Dram-road*, or *Waggon-way*, in *Rural Economy*, a track conſtructed of iron, ſtone, timber, or other material, upon the level ſurface of an inclined plane, or other ſituation, for the purpoſe of diminiſhing friction, and thus ſerving for the eaſy conveyance of heavy loads of any kind of articles. See *Plate* IV. *Canals, figs.* 31 to 35. See alſo CANAL.

It has been remarked, that railways have hitherto been confined, almoſt excluſively, to coal-works, and other mines; and that inventions, whoſe only recommendations are ſimplicity and uſefulneſs, are often ſuffered to lie long in a ſtate of public neglect; while others, perhaps, of no real utility, but of more impoſing aſpect, and being pertinaciouſly blazoned forth by intereſted or blinded partiſans, are readily adopted; and baſk, for a while, in the ſunſhine of public favour. The time has, however, at length arrived, when carriages moving on level ſurfaces, or on gently inclining planes, with little friction, and *without* obſtructions, are faſt ſpreading over the face of the country. It has been obſerved that there may be many lime-works, as well as other ſorts, from which railways may be laid, in different directions, with great benefit to their proprietors and the ſurrounding neighbourhoods in general.

With the view of diminiſhing horſe labour, it has been ſuggeſted by Dr. Anderſon, in his Recreations in Agriculture, that where internal canals cannot be eſtabliſhed, this may be effected, and intercourſe facilitated, by means of railways, which have not yet been introduced into general practice. It is further ſtated, that they were firſt ſolely employed for tranſporting coals to a moderate diſtance from the pits, to the places where they could be ſhipped, being univerſally made of wood. And long, ſays he, had they been applied to this uſe, without any idea having been entertained that they could be employed for more general purpoſes. By degrees they were, however, carried to a farther extent; the ſcarcity of wood, and the expence of their repairs, ſuggeſted the idea of employing iron for the purpoſe of improving theſe roads. At the firſt, flat rods of bar-iron were nailed upon the original wooden rails, or as they were technically called, *ſleepers;* and this, though an expenſive proceſs, was found to be a great improvement. But the wood on which theſe reſted being liable to rot and give way, ſome imperfect attempts were made to make them of caſt iron, but theſe were found to be liable to many objections, until the buſineſs was taken in hand by Mr. Outram, engineer, at Butterly Hall, Derbyſhire, who contrived at the ſame time, ſo far to diminiſh the expence, and improve the ſtrength of the road, as to bring them to a degree of perfection, that no one who has not ſeen them can eaſily conceive could have been done. And it is added, that this having been carried into execution in a few caſes, and found to anſwer, has been improved upon and ſimplified by practice, till it is now brought to ſuch a ſtate of perfection as to have given proofs, that it admits of being carried much beyond the limits of what was for many years conceived to be poſſible, and to afford demonſtrative evidence, that it may be in future employed to a wider extent ſtill, to which no limits can be at preſent aſſigned or foreſeen.

There are a great number of railways in Derbyſhire, Shropſhire, Lancaſhire, and many other parts of the country.

In the firſt of the above counties, there are railways of very different lengths; one of five miles in length, leading from the town of Derby to the collieries in the vicinity; another, from the lime-ſtone rocks on the Cranford canal, called the Crick railway, which is about one mile and a half in length; a third from the Beggarlee colliery to the ſame canal, denominated Barber and Walker's railway, of ſimilar length; a fourth from the lime-works in the neighbourhood of Boſton, to the canal near Whaley bridge, termed the Peak-foreſt railway, which is about ſix miles in length; a fifth called the Marple railway, of about one mile and a half long, on the Peak-foreſt canal; ſixthly, railways over Bliſworth-hill near Nottingham, on the Grand Junction canal, which are three miles and a half in length, and conſtructed in a double manner; a ſeventh, which has the name of the Aſhby de la Zouch railway, has four miles of double and eight miles of ſingle rails. Some of theſe railways are formed in a very complete manner, eſpecially thoſe which have been made ſince the various improvements of them were introduced. They have been of prodigious utility and advantage to the county, both in regard to its agricultural improvements and its manufacturing intereſts and concerns.

Theſe ſorts of railway roads have likewiſe been introduced into many parts of the county of Salop, with vaſt benefit and ſucceſs to the different intereſts of the diſtrict. They have here had a new application, in being employed for the purpoſe of conveying heavy weights from different levels on canals.

Speaking of the great utility of canals in the carriage of various articles in this county, it is obſerved by Mr. Telford, an able engineer, that another mode of conveyance has frequently been adopted to a conſiderable extent; which is that of forming roads by means of iron rails laid along them, upon which materials are carried in waggons, which contain from ſix to thirty hundred weight; experience, he thinks, has now convinced us, that in countries the ſurfaces of which are rugged, or where it is difficult to obtain water for lockage, where the weight of the articles of the produce is great in compariſon with their bulk, and where they are moſtly to be conveyed from a higher to a lower level, that in thoſe caſes, iron railways are in general preferable to canal navigation.

It is ſuppoſed, that on a railway well conſtructed, and laid with a declivity of fifty-five feet in a mile, one horſe will readily take down waggons containing from twelve to fifteen tons, and bring back the ſame waggons with four tons in them. This declivity, therefore, ſuits well, when the imports are only one-fourth part of what is to be exported. If the empty waggons only are to be brought back, the declivity may be made greater; or an additional horſe applied on the returning journey will balance the increaſe of declivity. If the length of the railway were to be conſidered, it may, it is ſuppoſed, without much inconvenience, be varied from being level to a declivity of one inch in a yard, and by dividing the whole diſtance into ſeparate ſtages, and providing the number of horſes ſuitable for each portion of railway, according to the diſtance and degree of declivity, the whole operation may be carried on with regularity and diſpatch.

It is upon the whole believed, that this uſeful contrivance may be varied ſo as to ſuit the ſurface of many difficult countries, at a comparatively moderate expence. It may be conſtructed in a much more expeditious manner than navigable canals; it may be introduced into many diſtricts where canals are wholly inapplicable; and in caſe of any change in the working of mines, pits, or manufactories, the rails may be taken up and laid down again in new ſituations, at no very great expence or trouble.

It is alſo further noticed, that ſome parts of this and the neighbouring counties, in which canals had once been

intended to be formed, have ſince been looked over and examined with the view of having iron railways inſtead of navigable cuts; and in many caſes this may be the moſt adviſable and proper, particularly in all ſituations where difficulties ariſe in the conſtructing of navigable canals, or other ſorts of works for water carriage.

The county of Lancaſter, too, has a great many of theſe iron railways for the convenience, accommodation, and advantage of the different collieries, manufactories, and other works, where heavy loads are to be tranſported. The coal work near St. Helans, in the vicinity of Liverpool, has a double railway ſome miles in length; and at the iron-works of lord Belcarras, near Wigan, as well as his cannel coal pits near the ſame place, there are double railways of very conſiderable length. To the ſouth of the town of Preſton, at a ſmall diſtance from Bamber bridge, there is likewiſe one communicating with the Lancaſter and Kendal canal, which is alſo double and of great length; ſerving to convey the coals from the ſouthern parts of the county to that canal, in order to their diſtribution in the northern parts, and the adjoining diſtricts.

On the eaſt ſide of the ſame county they alſo prevail in many places, and are found of the greateſt uſe, being the means of diſpatching much buſineſs in a ready manner and without much expence of labour.

The utility of theſe railways has been found to be extremely great in other coal-works and canals, where they are at preſent very extenſively employed; and it has been ſuggeſted, that they may be applicable in other caſes, as for ſhortening the team labour of a farm ſo as to bring it within one day's journey, where more than one were formerly neceſſary, by which a great ſaving in labour and expence may be made. Alſo, in rendering the buſineſs of lime works more eaſy and expeditious in different inſtances. It has likewiſe been hinted by Mr. Beatſon, in the firſt volume of Communications to the Board of Agriculture, that they might be had recourſe to on roads where there are unavoidable riſes or falls, for taking up or letting down heavy loaded waggons or other carriages. It is obſerved, that near Colebrook Dale there is one at a ſmall diſtance from the iron bridge, upon which loaded boats are drawn up to a canal, two hundred and twenty feet above the level of the river Severn, and let down in a ſimilar manner into it, by which means twenty-two locks are ſaved, and the work executed in an expeditious manner. It is ſuppoſed, that this is the greateſt inclined plane in Europe, or perhaps in the world, for though they are much uſed in China in the place of locks, he has never heard of any of them being equal in height to this. The rails are beſt made of iron. It is added, that they have been found uſeful in improving ſoft, moſſy, boggy lands, on which horſes cannot travel; a rail road of this ſort having been formed through a peat moſs near Mancheſter by Mr. Wakefield, while it was under improvement, at the expence only of about three hundred pounds a mile, on which a ſingle horſe was capable of drawing with the greateſt facility ſeven waggons at once, each being loaded with about ſeven hundred weight of marle, bearing in the whole forty-nine hundred weight, and with the weight of the waggons upwards of three tons. This was performed, it is obſerved, over a place where a few months before a dog could hardly venture without the danger of being *ſwamped*. On the Ketley and other canals in the county of Shropſhire, vaſt advantages have been derived from laying railways upon inclined planes, and letting down and drawing up the different articles by means of machinery, as may be ſeen in the very able Agricultural Report of that diſtrict, where excellent repreſentations of them are given.

Beſides theſe different caſes of railways, another has been ſuggeſted by the writer of the Annals of Agriculture, which is that of having them laid from the ſtack-yards to the thraſhing machines, by which the grain may be conveyed to them at any time with eaſe and convenience, as well as any particular ſtack that may be wanted.

It is further ſtated by the ingenious Dr. Anderſon, that the beſt idea he can give of the benefit that may reſult to the community from the uſe of this kind of railways, will be from ſtating ſome facts reſpecting them, which were lately communicated to the Society of Arts by Mr. Wilkes, of Meaſham, near Loughborough, in Leiceſterſhire; a ſpirited and judicious agriculturiſt. He had a railway of this ſort made, which was about five miles in extent, leading from a coal-mine to a market. He found it ſo fully to anſwer his expectations after it was finiſhed, that he communicated to the above ſociety an account of ſome trials he had made of it, requeſting that ſuch of the members of that reſpectable inſtitution as were deſirous of information on that head, would do him the honour to witneſs ſome experiments that he wiſhed to make upon it, for the information of the public. A committee of the members was accordingly deputed for that purpoſe, and before them he ſhewed that a moderate ſized horſe, of about twenty pounds value, could draw upon it with eaſe down hill (the deſcent being one foot in a hundred) thirty-two tons, and without much difficulty forty-three, and ſeven tons up hill, independent of the carriages. The doctor concludes from theſe facts, that upon a perfect level a horſe could draw with eaſe from ten to twenty tons. It is obſerved, that Mr. Wilkes's railway, on which the experiments were made, was, from local circumſtances, laid upon wooden ſleepers, and is not ſo perfect as thoſe done upon ſtone. But it is added, that twenty tons are the load which ſuch a horſe could draw with eaſe, travelling at the uſual waggon rate, in boats upon a canal; ſo that the number of horſes required in this way will not be much, if at all, greater than on a canal. Certain advantages attach to this mode of conveyance, which do not ſo well apply to a canal, and *vice verſa*; but it is not his intention to draw a parallel between theſe two modes of conveyance. Nobody can entertain any doubt, he thinks, about the utility of canals where they are eaſily practicable. He only wiſhes to point out this as an eligible mode of conveyance where canals cannot be conveniently adopted.

It is further remarked, that it was cuſtomary at the firſt, to put the whole load to be drawn by one horſe upon railways into one waggon; but now, when the load is ſo much augmented, it has been found eligible to divide it into many parts, ſo that no one waggon ſhall carry more than one or two tons; by this method the weight is ſo divided, that the preſſure is never ſo great upon one point as to be in danger of too much cruſhing the road; the carriages can be made much more limber and light in all their parts, and they are much more eaſily moved, and more manageable in all reſpects than they otherwiſe would have been. And another advantage of this arrangement, which deſerves to be particularly adverted to, is, that it admits of ſhifting the carriages ſo as to leave a load, as it were, in parcels at different places where they may be required, without trouble or expence. This, when it comes to be fully underſtood and carried into practice, will, he thinks, be a convenience of ineſtimable value, a thing that has been always wanted, and never yet has been found though it has been diligently ſought for. The able writer has here endeavoured to illuſtrate its importance and utility in tranſporting goods from the wet docks now forming on the Iſle of Dogs to London, and in carrying roads to different diſtant parts of the country; in which

cafes, and in all where there is much bufinefs to be done, they would require to be double, one for going, and the other for coming upon, to prevent interruption and interference.

And he afterwards offers a few remarks, tending to fhew the practicability of the meafure, and to guard againft letting out upon a bad plan, which might, he fuppofes, in time to come, fruftrate the good that might have refulted from the undertaking; merely premifing, that he propofes thefe railways folely for the purpofe of conveying weighty loads, leaving the roads, as at prefent, open for coaches and light carriages.

Alfo with a view to difcover how far it may be practicable to introduce thefe iron railways into general ufe, he has made fome inquiries refpecting the expence of making them; and although this muft vary according to the abundance and goodnefs of materials, and other circumftances, the following ftatement may ferve to give fome general notions on that head. In the moft eligible fituation, where materials are abundant and good, and circumftances favourable, the loweft expence at which a *fingle* railway of this fort can be made, will be about one thoufand pounds a mile. But as a fingle railway muft be liable to great inconveniencies, unlefs under very particular circumftances, double railways ought to be confidered as the only ufeful fort. Thefe, for public purpofes, according to the opinion of the inventor, fhould be very fubftantially made. The metal ufed fhould be of the ftouteft fort, and of fubftance enough, not merely to carry the weights propofed, but to be equal to bear almoft any blow or fhock that they may be likely to experience; and, thus made, what they will lofe by ruft or wear, will be long ere it materially weakens them. Made after fuch a manner, in favourable fituations in the country, a double railway may, he thinks, coft about two thoufand pounds a mile, but in the neighbourhood of London, where the charge of every thing is high, and where they fhould be of the ftrongeft fort, we fhould fuppofe they might coft nearly three thoufand pounds a mile. It is bad economy, he thinks, to fave on articles of this fort at the firft; for the little expence thus laid out then will fave much in repairs: how fmall thefe repairs are, may be imagined from this circumftance, that when a road is thus made, the undertaker does not fcruple to fupply all that are broken, free of charge, for the firft three years. Say then that fuch a road coft three thoufand pounds a mile, this would bring a charge upon the turnpike of 150*l.* a-year; fay 50*l.* more for annual repairs; this is, in all, 200*l. per annum.* Compare this with the expence of keeping the prefent roads in repair. It has been fuggefted to him, that there is annually laid out in repairs upon the road from Hyde Park Corner to Hounflow, confiderably above one thoufand pounds a mile; fo that the difference of expence is, even at the beginning, very much in favour of railways: and were the money thus at firft expended to be gradually paid off, the tolls might thus be lowered almoft to nothing. And, he thinks, that a turnpike road cannot be made in almoft any fituation for lefs, as he is told, than 1000*l. per* mile; but where it is of confiderable width, as near great towns, it will run from 1500*l.* to 2000*l. per* mile; and in annual repairs, including the purchafe price of materials, carting them on the road, fpreading, raking off, and carting away again, from 100*l.* to 1000*l.* a mile. Say 1500*l.* prime coft, the intereft is 75*l.* and 150*l.* for repairs, the annual charge of fuch road will be 225*l.* This is an expence of 100*l.* a-year more than the other. But for the prefent, let us fuppofe that they will be equal, the extra charge for purchafing ground for a new waggonway, &c. being equal to that furplus; let us now fee what would be the difference of charge to the employers of thefe waggons in the two cafes. Suppofing the road to be fo much employed as that 100 waggons (or loaded carriages to the fame amount) pafs each day, carrying fix tons each, drawn by eight horfes; thefe, at one fhilling each waggon for toll (or two-pence a ton), would produce 5*l.* a day, or 1825*l* a-year; which, at the rate of eight miles for each turnpike, would be 228*l. per* mile, the furplus being produced by road horfes and light carriages. The charge then to the employer, for this ftage, muft be 1825*l.* and the keep of 800 horfes, befides fervants, incidental charges, and owner's profits for the tranfporting of 600 tons of goods a day. Say that the fame horfes travel two ftages a day, the turnpike money would be doubled; that is, 3650*l. per annum;* the keep of 800 horfes, at 2*s.* each *per diem*, is 29,200*l.* Thefe fums added make 32,850*l.*; owner's profit and incidental charges, fay 10 *per cent.*, 3285*l.*; in all 36,135*l.*, or, on 219,000 tons (being 600 tons a day), about one-fourth *per* ton. And fuppofing the fame quantity of goods carried on the railway, and the fame turnpike money paid, and that each horfe drew only fifteen tons, this would require only, he thinks, forty horfes; the keep of which, at 2*s.* a day, would be 1460*l.*, add the toll, 1825*l.* is 3285*l. per annum.* Owner's profit, &c. upon this fum 10 *per cent.* as above, 328*l.*; in all 3613*l.*, or about four-pence a ton. juft one-tenth part of the charge in the other cafe. He thinks, that when the object comes to be confidered in this point of view, few meafures that can be propofed will hold forth fuch an important national improvement as this would be. Confidered with regard to the confumption of the produce of the earth (an object at prefent deferving the fulleft attention, as this improvement can be applied to almoft every part of the country), it would, he fuppofes, reduce the number of heavy road horfes to one-eighth part of what they are at prefent, and of courfe augment the number of cattle or other confumeable provifions in a proportionate degree, fo as greatly to lower the price of the neceffaries of life. It would, in the next place, lower the price of the carriage of goods of all kinds to an amazing extent; and laftly, as a confequence of that, it would give fuch encouragement to agriculture, as no other meafure that can be contrived could ever effect, and that without cofting one fhilling expence to any one individual, or to the ftate. On the contrary, by inducing cheapnefs of provifion, and affording fuch efficacious encouragement to manufactures and to agriculture, it would produce a general profperity, which, by augmenting the confumption of taxable commodities, would augment the public revenue; while, at the fame time, every individual would feel himfelf relieved from the preffure of many taxes that prove diftrefsful to him at prefent. After juftly reprobating every fort of gambling fpeculations by monied men in undertakings of this nature, and fhewing the numerous evils that attend them, he advifes it, as highly neceffary to prevent thefe railways from ever becoming private property, on any account, to keep them open and patent alike, to all who fhall choofe to employ them as a king's highway, under fuch regulations as it fhall be found neceffary to fubject them to by law. In fhort, they fhould, he thinks, be put upon the fame footing, in all refpects, as public roads are at prefent, only under the direction of a diftinct fet of commiffioners, who fhould have the fuperintendance of every thing that concerns this fpecies of roads only. Thefe commiffioners fhould be vefted with authority under an act of parliament, to erect turnpikes upon them, to levy certain ftipulated tolls, and to mortgage the produce of thefe tolls for the purpofe of raifing money to be applied in the neceffary purchafes of land, and making the roads. In the act it

ſhould be expreſsly ſtipulated, that the produce of theſe tolls ſhould be applied ſolely to keeping the road in repair, paying the intereſt of ſums borrowed, and clearing off the principal as faſt as the collections would admit; and when the whole money borrowed was thus paid off, the tolls ſhould be ſo lowered as only to produce money ſufficient to keep the roads in a ſtate of continually good repair. Thus would the expence of tranſporting goods be annually diminiſhing, and the proſperity of the country be thereby augmenting from day to day. He adds, that he is particularly earneſt in this buſineſs, as he has not been an unconcerned obſerver of the effects that have reſulted from the eſtabliſhment of turnpike roads in Scotland, which were begun within his recollection; and theſe effects have been ſuch as no man who had not ſeen it would have believed could ever have taken place. Diſtance may be ſaid to be thus diminiſhed from place to place; lands that were originally far beyond the influence of the town as a market for any thing elſe than live-ſtock, are thus brought, as it were, cloſe to its gates; and the value of the produce of many articles is thus to them augmented fourfold, while they are at the ſame time diminiſhed to the public. Not only is the value of produce raiſed, but the quantity alſo of that produce is augmented exceedingly by means of manures which become then acceſſible. Foſſile manures, ſuch as chalk, lime, and marle, which were formerly confined to a narrow ſpot, expand themſelves as if it were by a magical power, and by that expanſible influence diffuſe around fertility, riches, and plenty. Coals and other weighty articles that may be uſeful in arts or manufactures of various kinds, which never were, nor ever could have been of any value to the owners of them, ſo long as the expence of tranſportation exceeded a certain ſum, find a ready market to any extent as ſoon as the price falls below that rate, thus contributing not only towards the enriching of the owners, but to the furniſhing of employment to the various perſons who muſt be engaged in preparing o tranſporting them to market, and the univerſal accommodation of the whole. Around every market you may ſuppoſe a number of concentric circles drawn, within each of which certain articles become marketable which were not ſo before, and thus become the ſource of wealth and proſperity to many individuals. Diminiſh the expence of carriage but one farthing, and you widen the circle; you form, as it were, a new reation, not only of ſtones, and earth, and trees, and plants, but of me. alſo and what is more, of induſtry, of happineſs, and joy It is added, that by making theſe roads the property of the public, and free to every perſon to bring his own waggons upon them wherever he pleaſed, farmers, when near them, would make bye roads of the ſame ſort leading into theſe from their reſpective premiſes; the inhabitants of villages and country diſt ould join together, and at one common expence make roads of the ſame ſort leading to a greater diſtance inwards, as they now make bye roads for themſelves. Thus would all be accommodated; thoſe who had buſineſs enough to furniſh a ſufficient load for one horſe might go to market with it when they pleaſed: thoſe who had dealings on a ſmaller ſcale could have one, two, or more waggons of their own conjoined with thoſe of others to make up a load for one horſe: and thoſe of ſtill ſmaller means could have one waggon loaded with the joint articles belonging to two, three, or more. A ton weight might then be puſhed before a man to market for many miles, as a wheelbarrow is now. It is ſcarcely poſſible, he ſuppoſes, to contemplate an inſtitution from which would reſult a greater quantum of harmony, peace, and comfort, to perſons living in the country, than would naturally reſult from this arrangement. In fact, he knows, he ſays, no *one* meaſure, that would tend ſo effectually to lower the price of the neceſſaries of life, and reſtore abundance.

In what regards the method of forming and conſtructing theſe railways, it is obſerved by the ſame writer, that the following has been given by the inventor as the moſt improved plan: firſt, that the beſt line the country affords ſhould be traced out, having regard to the direction of the carriage of articles or trade to be expected; and if ſuch trade be both ways in nearly equal quantities, a line as nearly horizontally level as poſſible ſhould be choſen. If the trade is al' ne direction, as is generally the caſe between mines and navigation, then the moſt deſirable line is one with a gentle gradual deſcent, ſuch as ſhall make it not greater labour for the horſes employed to draw the loaded waggons down, than the empty ones back; and this will be found to be the caſe on a railway deſcending about one foot vertical in one hundred feet horizontal. Or, if the railway and carriages are of the very beſt conſtruction, the deſcent vertical may be to the length horizontal as 1 to 50, where there is little or no upgate loading. In caſes between mines and navigations the deſcents will often be found greater than could be wiſhed. On a railway on the improved plan, where the deſcent is more than as 1 to 50, ſix or eight waggons, loaded with thirty or forty hundred weight each, will have ſuch a tendency to run downwards, as would require great labour of one horſe to check and regulate, unleſs that tendency was checked by ſledging ſome of the wheels. On ſuch, and ſteeper roads, iron ſlippers are applied, one or more to a gang of waggons, as occaſion may require. Each ſlipper being chained to the ſide of one of the waggons, and, being put under the wheel, forms a ſledge Where the deſcent is very great, ſteep inclined planes with machinery, may, it is obſerved, be adopted, ſo as to render the other parts of the railway eaſy. On ſuch inclined planes the deſcending loaded waggons being appl d to raiſe the aſcending empty, or partly loaded ones, the neceſſity of ſledging the wheels is avoided; and the labour of the horſe greatly reduced and leſſened.

In order to obtain the deſired levels, gentle deſcents, or ſteep inclined planes, and to avoid ſharp turns, and circuitous tracks, it will often be found prudent to croſs valleys by bridges and embankments; to cut through ridges of land; d in very rugged countries ſhort tunnels may, he thinks, ſometimes be neceſſary. The line of railway being fixed, and the plans and ſections by which the ſame is to be executed and ſettled, the ground for the whole muſt be formed and effectually drained. The breadth of the bed for a ſingle railway, ſhould be, in general, four yards; and for a double one ſix yards, excluſive of the fences, ſide drains, and ramparts.

That the bed of road being ſo formed to the proper inclination, and the embankments and works thereof made firm, the ſurface muſt be covered with a bed of ſtones broken ſmall, or good gravel, ſix inches in thickneſs or depth. On this bed muſt be laid the ſleepers, or blocks to faſten the rails upon. Theſe ſhould be of ſtone in all places where it can be obtained in blocks of ſufficient ſize. They ſhould be not leſs than eight, nor more than twelve inches in thickneſs; and of ſuch breadth (circular, ſquare, or triangular,) as ſhall make them 150lbs. or 200lbs. weight each. Their ſhape is not material, ſo as they have a flat bottom to reſt upon, and a ſmall portion of their upper ſurface level, to form a firm bed for the end of the rails. In the centre of each block ſhould be drilled a hole, an inch and a half diameter, and ſix inches in depth, to receive an octagonal plug of dry oak, five inches in length; for it ſhould not reach the bottom of the hole; nor ſhould it be larger than ſo as to put in

eafily, and without much driving; for if too tight fitted it might when wet burft the ftone. Thefe plugs are each to receive an iron fpike or large nail, with a flat point and long head, adapted to fit the counter-funk notches in the ends of two rails, and thereby to faften them down in the proper pofition, or fituation in which they are to lie.

With regard to the rails, they fhould be of the ftouteft caft-iron, one yard in length each, formed with a flanch on the inner edge, about two inches and a half high at the ends, and three and a half in the centre; and fhaped in the beft manner to give ftrength to the rails, and keep the wheels in their track. The foles of the rails, for general purpofes, fhould not, he thinks, be lefs than four inches broad; and the thicknefs proportioned to the work they are intended for. On railways for heavy burdens, great ufe, and long duration, the rails fhould be very ftout, weighing 40lbs., or, in fome cafes, nearly half an hundred weight each. For railways of lefs confequence, lefs weight of metal will do; but it will not be prudent to ufe them of lefs than 30lbs. weight each, in any fituation expofed to breakage above ground. But it is obferved that in mines, and other works under ground, where very fmall carriages only can be employed, very light rails are ufed, forming what are called train roads, on a fyftem introduced by Mr. Carr; and thefe kinds of light railways have been much ufed above ground in Shropfhire, and other counties where coals and other minerals are obtained.

It is added, that in fixing the blocks and rails great attention is required to make them firm. No earth or foft materials fhould be ufed between the blocks and the bed of fmall ftones or gravel, on which the rails muft all be fixed by an iron gage, to keep the fides at a regular diftance, or parallel to each other. The beft width of road for general purpofes is four feet two inches between the flanches of the rails; the wheels of the carriages running in tracks about four feet fix inches afunder. Rails of particular forms are neceffary where roads branch out from or interfect each other; and where carriage roads crofs the railways; and, at turnings of the railways, great care is required to make them perfectly eafy. The rails of the fide forming the inner part of the curve fhould be fixed a little lower than the other; and the rails fhould be fet a little under the gage, fo as to bring the fides nearer together than in the ftraight parts: thefe deviations in level and width to be in proportion to the fharpnefs of the curve. The blocks and rails being fixed and fpiked faft, nothing more remains to be done than to fill the horfe-path, or fpace between the blocks, with good gravel, or other proper materials; a little of which muft alfo be put on the outfide of the blocks to keep them in their proper places. This gravel fhould always be kept below the furface of the rails on which the wheels are to run, to keep the tracks of the wheels free from dirt and obftructions. The form of the rails muft be fuch as will free them from dirt if the gravelling is kept below their level.

And in the conftructing of the carriages great attention to avoid friction is neceffary, particularly in the formation of the wheels and axles, which muft be adapted to the fort of railways and kind of loading; but for which general directions cannot be given in a narrow compafs. It is probable that this valuable invention may alfo be applicable to many other purpofes in agriculture or manufactures, as it becomes more fully underftood, and the facilities which it affords are better known. See Canal.

Red

RED, in *Physics*, one of the simple or primary colours of natural bodies, or rather of the rays of light.

The red rays are those which are of all rays the least refrangible: hence, as sir Isaac Newton supposes the different degrees of refrangibility to arise from the different magnitudes of the luminous particles of which the rays consist, the red rays, or red light, is concluded to be that which consists of the largest particles. See COLOUR, LIGHT, and RAY.

Authors distinguish three general kinds of red; one bordering on the blue, as colombine, or dove-colour, purple, and crimson; another bordering on yellow, as flame-colour and orange; and between these extremes is a medium, partaking neither of the one nor the other, which is what we properly call *red*.

Acids generally turn black blue, and violet into red; and red into yellow, and yellow into a very pale yellow.

Alkalies change red into violet, or purple; and yellow into feuillemort, or dead leaf-colour.

Terrestrial and sulphureous matters become red by extreme heat; and some, at length, black, as we see in brick, red bole, red chalk, slate, &c. All these, when vitrified by a burning-glass, become black.

Lobsters become red by a moderate fire; and by a violent one, black. Mercury and sulphur mixed and heated over a moderate fire make a beautiful red, called *artificial cinnabar*.

An acid spirit, as lemon juice, being poured on a blue solution of turnsole, turns it into a beautiful red. Alkali restores it again to its original blue. Filtrating of some reddish wines takes from them all their red colour.

M. De la Hire observes, that a very luminous body viewed through a black one, always appears red; as when the sun is seen shining through a black cloud. He adds, that some people who see all the other colours perfectly well, yet have no idea of red, and only see it as black.

RED, in *Cosmetics*, a fucus or paint with which the ladies enliven their cheeks and lips.

There are two kinds of reds; the one in leaves, called Spanish red; the other a liquor, which is an extract of a scarlet dye.

Red, in *Dyeing*, is one of the five simple or mother colours of the dyers.

Some reckon seven kinds, or casts of red: *viz.* scarlet-red, crimson-red, madder-red, half-grain-red, half-crimson-red, lively orange-red, and scarlet of cochineal. But they may be all reduced to three, according to the three principal drugs which give the colours; which are kermes, cochineal, and madder.

The fine scarlet, called *scarlet of the Gobelins*, is given with agaric, bran-water, woad, and scarlet grain, or kermes. Some dyers add cochineal, and others fenugreek; brightening it with bran-water, agaric, tartar, and turmeric. See Kermes and Scarlet.

Crimson-red is dyed with bran-water, tartar, and mestique cochineal. See Crimson.

Madder-red is dyed with madder; to which some add realgar, or red arsenic: others, common salt, or other salts, with wheat-flour; or agaric with spirit of wine, with galls or turmeric. See Madder.

The half-grain is made with agaric and bran-water, half scarlet grain, half madder, and sometimes turmeric.

The half-crimson is made of half madder, half cochineal. As to the lively orange-red, the stuff must be first put in yellow, then in a liquor made of goat's hair, (which has been boiled several times with madder,) dissolved over the fire with certain saline liquors, as urine, tartar, &c.

The scarlet of cochineal, or Dutch scarlet, as the French call it, is made with starch, tartar, and cochineal; after first boiling it with alum, tartar, sal gemma, and aqua fortis in which pewter has been dissolved.

Besides these seven reds, which are good and allowed colours, there is also a Brasil red; which is discouraged, as fading easily.

Of the seven good reds, only four have particular casts, or shades; the madder-red, crimson-red, lively orange-red, and scarlet of cochineal.

The casts or shades of crimson are flesh colour, peach colour, carnation rose colour, and apple-tree flower colour. Those of madder are flesh colour, onion-peel colour, and flame colour. Those of orange are the same with those of crimson. Scarlet, besides the shades of all the rest, has some peculiar to itself, as cherry colour, fire colour, &c. See Dyeing.

Red, in the *Manufacture of Glass*. See *Red* Glass.

To make a deep red in glass, the following method is that most practised by the glass-men. Take crystal frit twenty pounds, broken pieces of white glass one pound, calcined tin two pounds; mix these well together, and put them into a pot to melt and purify. When these are melted, take steel calcined, scales of iron from the smith's anvil, both powdered very fine, of each an equal quantity; put leisurely an ounce of this mixed powder to the before mentioned metal; mix all well together, and let them stand six or eight hours in fusion to incorporate; take out a proof after this, and if there be too little of the powder, it will appear of a dusky yellow; then more of the powder must be added, and then add three quarters of an ounce of calcined brass, ground to a fine powder; mix them thoroughly together, and the mass will be of a blood red; continue stirring the whole together, and frequently taking out proofs of the colour, when it is right, work it immediately, otherwise it will lose its colour and become black. The mouth of the pot must in this process be left open, else the colour will be lost. Neri's Art. of Glass, p. 100.

Red, in *Heraldry*. See Gules.

Red, in *Painting*. For painting in oil colours they use a red called *cinnabar*, or vermilion; and another called *lacca*. See each in its place.

In limning and fresco, for a violet red, instead of lacca they use reddle, a natural earth found in England; for a brown red, they use burnt ochre, which is a native yellow earth, made red by calcination. It is chiefly brought from Oxfordshire; and burnt by those who prepare it in large ovens. The marks of its goodness are brightness of colour, and a friable chalky texture, without manifesting any gritty roughness when rubbed betwixt the fingers.

The common Indian red, which is of a hue verging to the scarlet, is much used, on account of its standing and warm though not bright colour, in finer as well as coarser paintings in oil. It may be prepared by taking of the caput mortuum or ochre left in the iron pots after the distillation of aqua fortis from nitre and vitriol, two parts; and of the caput mortuum or colcothar left in the long necks after the distillation of oil of vitriol, one part; breaking the lumps found among them, and putting them into tubs with a good quantity of water: and having left them to stand for a day or two, frequently stirring them, then lading off as much water as can be obtained clear from them, and adding a fresh quantity; repeating the same treatment till all the salts be washed out, and the water comes off nearly insipid. The red powder which remains must then be washed over, and, being freed from the water, laid out to dry. When this is designed for nicer purposes, it should again be washed over in basons.

The true Indian red is a native ochreous earth of a purple colour, brought from the island of Ormus, in the Persian gulf; and called, among the authors on these subjects, *terra Persica*. At present it is very rarely to be found; but it is certainly very valuable (there being no other uncompounded purple colour in use with oil) as well for the force of its effect, as for the certainty of its standing. In its genuine state, it needs no other preparation than grinding or washing over. It may be easily distinguished from any fictitious kind, by its being more bright than any other ochre which can be made so purple; and if it be rendered artificially purple by any addition, the fire will soon betray it; into which the genuine may be put without any hazard of change.

Venetian red is a native red ochre (see Veneta *bolus*), not much different from the common Indian red, but fouler; and may be easily prepared, by mixing common red ochre with the colcothar or caput mortuum taken out of the aqua fortis pots, and washed over. As it is generally used by the house painters in imitation of mahogany, it requires no other preparation than to be well ground with the oil with which it is used; but when it is used in miniature painting, it should be carefully washed over.

Red, *Blown*, in the *Porcelain Manufacture*, a name given to a peculiarly coloured china ware, of a spangled red, or to the colour alone that spangles it. It is an ornament easily introduced into use in our own manufactories of porcelain ware, and is done in the following manner. The colour is to be prepared of common copperas, calcined to a red colour in a charcoal fire, in a crucible, with another luted on the top of it inverted, and with a hole in its bottom. The signal of the calcination being finished, is, when the black clouds cease to come up through the hole, and a fine white thin vapour rises in their place. The vessels are to be then suffered to cool, and the red matter in them is to be reduced to a fine powder, while the vessels to be coloured with this

are yet wet. The operator is to provide a glaſs pipe, and covering one end of it with a piece of fine gauze, he is to dip this into the powder, and taking it carefully out, with what little is ſticking to it, he is to blow againſt the veſſel at ſome diſtance from it: thus the fineſt part of the powder only will reach the veſſel, and will be laid on in form of glittering ſpangles, very ſmall, but all diſtinct. This is ſort of colouring much eſteemed by the Chineſe themſelves, and they have a way of uſing the common blue in the ſame manner; but few of the veſſels thus painted come over to us.

Refining

REFINING, in *Metallurgy* and *Aſſaying*. In the former it ſignifies the means of obtaining metals from their ores, and from any other impurities, natural or artificial: for which ſee the metals under their reſpective heads. In the latter it is employed for aſcertaining the quantity of the noble metals in the different alloys: for which ſee CUPEL; where the methods of refining in the furnace are fully treated. And for the humid proceſs called *parting*, ſee GOLD.

It may be proper here to obſerve, that although the proceſs of parting by nitric acid is ſtill practiſed, we are inclined to recommend the method propoſed by Bergmann, which conſiſts in diſſolving the alloy of gold and ſilver in nitro-muriatic acid. The ſilver falls to the bottom in the ſtate of muriate of ſilver, and the gold is precipitated by the green ſulphate of iron. The gold, by this means, is obtained perfectly pure, which is ſeldom the caſe in the proceſs of parting. The trouble of teſting to know what ſilver to add to the alloy, to make the gold equal to one-fourth of the ſilver, will be ſaved, and, with heat, the nitro-muriatic acid diſſolves the gold quite as ſoon as the ſilver is diſſolved in the common method. The muriate of ſilver, which is eaſily ſeparated by waſhing, may be readily reduced by heating it with ſoda in an iron crucible. The ſoda combines with the muriatic acid, and is ſublimed in white fumes.

REFINING *of Sugar*. This operation is begun by ſeveral ſtrong lixiviums or leys of lime-water and eggs, ſhells and all, mixed and beaten together.

The firſt refining is performed in the Caribbees, and other places, where the ſugar-canes are cultivated; and only ſerves to make the brown or coarſe ſugars.

When theſe are imported into Europe, the ſugar-bakers take them up, and refine them farther, by a ſecond operation, or rather a repetition of the firſt.

To render the ſugar very fine, fit for confections, &c. they give it a third refining; in which they only uſe the whites of eggs and their ſhells beaten together, and thrown into the melted ſugar; which is called *clarifying the ſugar*. See SUGAR.

REFINING *of Salt-petre*. The ſalt being put into an earthen or iron veſſel, as much ſpring-water is poured on it as ſuffices to diſſolve it. The veſſel is then put over a gentle fire; and as ſoon as the water begins to boil, alum powder is thrown into it: the proportion is, one pound of alum to one hundred and twenty-eight pounds of ſalt-petre; and a little vinegar is added. As it boils, the ſcum is to be taken off; and it is to be evaporated till a pellicle appears on it, and then ſet to ſhoot.

For the refining of other matters, as camphor, cinnabar, ſulphur, ſalt, borax, &c. ſee CAMPHOR, CINNABAR, SULPHUR, SALT, &c.

Regulator

REGULATOR *of a Watch*, is a fmall fpring belonging to the balance, ferving to adjuft the going, and to make it go either fafter or flower.

REGULATOR *of Velocity*, in *Mechanics*, is a contrivance for regulating or governing the motion of a mill, or other large machine, by means of which it will always be caufed to preferve an equable and regular velocity in the motion of its parts, notwithftanding any accidental increafe of the moving force, or decreafe of the refiftance that may occafionally arife. A regulator muft be connected with fome lever, or other parts of the machine, which commands the fupply of whatever conftitutes its moving force, as the fhuttle of a water-wheel, the fail-cloth of a wind-mill, or valve of a fteam-engine; and it fhould have the property of acting fuddenly upon this lever, or other part, the inftant any increafe or decreafe of velocity in the motion takes place, either to elevate or deprefs it, and thus regulate the fupply in a degree proportioned to the quantity of alteration in the velocity; and it is by the fenfibility and accuracy of the regulator in this refpect that its perfection is eftimated.

The regulator moft commonly ufed is called a *governor.* This confifts of two or more pendulums fufpended from joints, which are fupported upon a vertical axis: this being caufed to revolve by the machine, and the pendulums accompanying it, the balls will, by the centrifugal force, recede from the axis or centre a quantity proportioned to the velocity of the motion and length of the pendulum: then, on any acceffion of the motion, they recede ftill further from the axis, or *vice verfâ*, if the velocity diminifhes. This motion is contrived to actuate the lever which regulates the velocity of the machine in a fteam-engine: it is connected with the valve which admits the fteam from the boiler to the cylinder, in a water-wheel with the fhuttle, through which the water flows, or in a wind-mill with the mill-ftones, or fail-cloths. See a farther defcription under MILL-WORK, STEAM-*Engine*, and WINDMILL.

The principle of the governor is the fame with the circular or conical pendulum, of which Huygens has laid claim to the invention, as well as of the long pendulum for regulating clocks, who fays he difcovered it nearly at the fame time as the other. The conical pendulum circulates feconds when of the fame length with the common pendulum, which will vibrate only half feconds. To explain it, we muft fuppofe a ball or weight to be fufpended by a ftring or rod, fo that the ball can defcribe in a horizontal circle by a motion of the rod round a vertical axis, with which the centre of fufpenfion coincides. In this motion the rod of the pendulum will defcribe the furface of a cone, of which the point of fufpenfion is the vertex, and the horizontal circle which the ball defcribes is the bafe: it is hence called the circular or conical pendulum. The ball has liberty to recede from, or approach to, the axis, by moving upon its centre of fufpenfion, and thus the circle the ball defcribes will be enlarged or diminifhed; and it is this circumftance which gives it the property of circulating or performing a revolution always in the fame fpace of time which a fimple pendulum of four times the length would vibrate; for this takes place equally whether the ball is extended to defcribe a large circle, or retracted to revolve in a fmall one; though, it fhould be obferved, that this is only true in the fuppofition that the pendulum-ball, in moving from the vertical axis upon its centre, will defcribe a parabola inftead of a circle, in the fame manner as the ball of a common pendulum is required to move in the arc of a cycloid inftead of a circle, to caufe all the vibrations, both long and fhort, to be performed in equal fpaces of time. Mr. Martin has, in his Inftitutions, given a very complete explanation of the principle of this pendulum, by fuppofing an inverted parabola, with its axis placed in a vertical pofition; then fuppofing a bowl or veffel excavated by the revolution of this figure upon its axis a paraboloid will be formed. A heavy globe or ball being put in this bowl, may, by agitating the veffel, be caufed to perform a revolution in a horizontal circle within the veffel, and it will be found to circulate in the fame period of time, whether it defcribes a fmall circle near the bottom of the veffel, or a large circle in its upper part, where the diameter is larger.

The governor or flying-ball is the regulator moſt generally uſed in machinery, although there are other means which, in particular inſtances, are preferable, from the circumſtance of their poſſeſſing a greater power to operate upon the regulating part of the machine. One of theſe, called the water-regulator, conſiſts of a pump, which, being worked by the machine, will raiſe water into a ciſtern, from which a conſtant ſtream flows off by a pipe and cock; a float is placed upon the ſurface of the water in the ciſtern, and this communicates with the ſteam-valve of the engine, or ſhuttle of the water-wheel. The operation of this regulator is eaſily explained, for the pump will raiſe a quantity of water exactly proportioned to the velocity of the machine, or the number of ſtrokes it makes; whereas the ſtream which flows off by the cock is a conſtant quantity, and equal to that which the pump will ſupply when the machine moves with its intended velocity. When this is the caſe, the ſurface of water in the ciſtern will ſtand at the ſame height; but if the velocity is increaſed, the pump will raiſe more water into the ciſtern than the pipe and cock will carry off, and the ſurface riſing, elevates the float, which, by its action to diminiſh the ſupply of power to the machine, will correct the acceleration which had taken place in its velocity. The oppoſite effect takes place if the velocity decreaſes, *viz.* that the ſupply to the ciſtern being diminiſhed whilſt the efflux is conſtant, the ſurface will ſink, and the float deſcending, opens the valve or ſhuttle, and increaſes the ſupply of power to the machine until it regains the original velocity. The great advantage of this regulator is, that it can ſo readily be made to keep the machine ſteady at any velocity which may be required, and this by merely opening or cloſing the cock: thus, if it is opened to carry off a greater quantity, the ſurface will ſubſide, and the float, by deſcending, opens a greater ſupply of power to the machine, and occaſions it to move quicker; but this, though it raiſes more water by means of the pump, will not raiſe the ſurface of the water in the ciſtern to ſo great a height as it ſtood at before, becauſe the efflux is now equal to the increaſed ſupply.

In all caſes this regulator will cauſe the machine to work at ſuch a rate, as to make the pump raiſe the ſame quantity of water as the cock emits, and its rate may be aſcertained before it is put to work; for if the quantity of water which the cock will diſcharge in a minute, or other given ſpace of time, is known, and the dimenſions of the pump; then it may eaſily be calculated what number of ſtrokes *per* minute the pump muſt make to raiſe an equal quantity of water. The ſenſibility of this regulator will be increaſed by making the ciſtern of a ſmall ſize, becauſe then any deviation from the intended rate of working will cauſe the greater elevation or depreſſion of the ſurface, and a greater action on the float: and, for the ſame purpoſe, it is beſt to make the ciſtern gradually diminiſh in area, ſo as to be ſmaller both towards the top and at the bottom, than at the place where the ſurface is expected to ſtand when the machine moves with the proper velocity. By this means it will riſe or fall more rapidly, in conſequence of the diminiſhed area of the ciſtern, when the alteration of velocity is conſiderable, and a greater correction is required, than when the alteration is only trifling. It is neceſſary that the pump ſhould raiſe a conſtant ſtream of water into the ciſtern, both in the aſcent and deſcent of its bucket: to do this, two pumps, acting alternately, may be uſed, or by a very ſimple contrivance a ſingle pump may be made to effect the ſame; thus, upon the rod of the pump a cylinder of wood is fixed, which is of ſuch a diameter, that its area is equal to half the area of the pump-barrel, and its length being equal to the length thereof, its content will be equal to one-half of the barrel: this is fixed on ſuch a part of the rod, that it will, by the riſing and falling of the rod, be drawn up out of water as much as the rod and bucket moves: now, when the pump-bucket is drawn up, the riſing of the cylinder above the ſurface of the water increaſes the capacity of the ciſtern one-half as much as the quantity of water which is thus drawn up into it, and the efflux of water by the cock being juſt equal to the other half, the ſurface will be ſtationary; and when the bucket deſcends, and no water is raiſed, the cylinder going down into the water diminiſhes the capacity of the ciſtern a quantity equal to the quantity of water which will flow off in the ſame time, and thus ſupplies the waſte of water which flows off in the ſame time. A regulator of this kind may, in many caſes, be formed from ſome part of the machine, without any additional apparatus: thus, the cold water-pump of a ſteam-engine will raiſe the neceſſary water into a ciſtern for the float to act in, and this float muſt be connected with the arm of the ſteam-valve. Alſo, in an engine for blowing a furnace, where it has a water-regulator (ſee Blowing), the riſe of the water in the external ciſtern may regulate the motion of the engine, the whole machine being of the ſame kind with the regulator we have deſcribed.

A regulator would be applied with great advantage to a machine which is uſed in the *Cotton* Manufacture (ſee that article), for drawing a piece of cotton cloth regularly and ſlowly over a red-hot cylinder of iron by two rollers, from one of which it is wound to the other: now, if the men who turn theſe ſtop but for a moment the cloth is burnt through, but by a regulator it might be lifted off the hot iron the inſtant the motion was ſo far diminiſhed as to endanger the firing of it.

The water-regulator is rendered more powerful by ſuſpending the ciſtern from the end of a lever, like a ſcale-beam, the oppoſite end of which has a counterpoiſe ſufficient to balance the weight of the ciſtern when the water in it ſtands at the intended height; but if the water increaſes in the ciſtern from the cauſes above deſcribed, the box will deſcend, and the motion of the lever will act upon the machine to make the regulation the ſame as the motion of the float: on the other hand, when the water in the ciſtern diminiſhes, the counterpoiſe will draw it up and give motion to the lever. The water from the pump is introduced to the ciſtern by a ſpout, and all the other parts have the ſame conſtruction as we have deſcribed.

It is a defect of both the regulators we have above deſcribed, that they do not operate upon the machine until the alteration of velocity has actually taken place, although they immediately correct it. It would be deſirable to have others which would make the correction before the evil takes place: for inſtance, in a wind-mill, which is more ſubject to irregularity than any other machine, a large vane may be ſuſpended by a heavy pendulum, and oppoſed to the wind; now the force of the latter, when blowing regularly, will cauſe the pendulum to incline a certain quantity from the perpendicular; but if the wind increaſes or diminiſhes, it will incline more or leſs, and this motion may be communicated to the ſhuttle which regulates the feed of corn, ſo as to give more or leſs to the ſtones in proportion to the power of the wind for grinding it, thus adapting the reſiſtance to the power; and if this ſhould increaſe beyond all bounds, the ſame motion may be made to act upon the grip of the mill to check its acceleration effectually. In the ſame manner a water-wheel may have a float placed in the dam or head to act upon the ſhuttle whenever the ſurface thereof riſes or falls above or

below the intended level, fo as to apportion the fupply to the fall, and keep the velocity uniform.

There is another kind of regulator fometimes ufed in machines to caufe a fufficient refiftance to the motion to prevent acceleration, fuch as a crane or lowering machine, which is to let down a heavy weight, a coal winding machine, &c.; a very good one for thefe purpofes is a vertical axis with pendulums, like the governor, but having a broad vane to meet the air inftead of heavy balls, which indeed may be added alfo: this, when put in motion, will oppofe a very great refiftance to the acceleration, becaufe the centrifugal force caufing the vanes to recede from the centre, they muft defcribe a larger circle in the air in proportion to the velocity, or, by collapfing, they make but little refiftance when the velocity is fmall.

Rentering

RENTERING, Fine-drawing, in the *Manufactories*, the ſewing of two pieces of cloth, edge to edge, without doubling them; ſo as that the ſeam ſcarcely appears at all: hence it is called *fine-drawing*.

The word is formed from the French, *rentraire*, which ſignifies the ſame thing; and which Menage, after Salmaſius, derives from the Latin, *retrahere*, of *re*, *in*, and *trahere*, by reaſon the ſeam is drawn out of ſight, and covered.

Serges, &c. are to be ſewed: cloths fine-drawn. The author of one of the Let. Edif. et Cur., ſpeaking of the great dexterity of the fine-drawers in the Eaſt Indies, aſſures us, that if you tear a piece of fine muſlin, and give it one of them to mend, it ſhall be impoſſible for you to diſcover the place where it is rejoined, even though you had made a mark to know it by.

The dexterity of our own fine-drawers, though inferior to that above-mentioned, is nevertheleſs ſuch, as puts them in a condition to defraud the king, by ſewing a head or ſlip of Engliſh cloth on a piece of Dutch, Spaniſh, or other foreign cloth; or a ſlip of foreign cloth on a piece of Engliſh, ſo as to paſs the whole, as of a piece; and by that means avoid the duties, penalties, &c. The trick was firſt diſcovered in France by M. Savary, author of the Diction. de Commerce.

To renter, in *Tapeſtry*, is to work new warp into a piece of tapeſtry damaged, eaten by the rats, &c. and on this warp to reſtore the ancient pattern, or deſign. The warp is to be of woollen, not linen. Among the titles of the French tapeſtry-makers, is included that of renterers.

Fine-drawing is particularly uſed for a rent, or hole, happening in the dreſſing or preparing of a piece of cloth, artfully ſewed up or mended with ſilk.

All fine-drawings are reputed defects or blemiſhes; and ought to be allowed for in the price of the piece. Hence, M. Savary eſtabliſhes it as a rule, which is certainly founded on natural equity, that every manufacturer mark the fine-drawings of his cloth with a piece of packthread tied to the liſt; to direct the draper to the ſpot: and that the draper apprize the taylor, or other perſon to whom he ſells it, of the ſame, that he may not come to damage in the cutting; there being inſtances of drapers condemned to take back their cloth, when cut to pieces, for omitting to mention the fine-drawings, and other flaws.

On this occaſion. M. Savary extols the procedure of an Engliſh merchant, who, ſending a piece of cloth damaged in one ſpot, to his correſpondent at Paris, put a piece of gold in the damaged place, to make up the damage. But as this example is perhaps the only one of its kind, that author recommends it to the merchant, or draper, to unfold all the pieces entirely, as they come to him; to diſcover the fine-drawings, and other flaws, in order to make the clothier accountable for them.

Road

ROAD, Via, an open way or paſſage, forming a commodious communication between one place and another.

The Romans, of all people, took the moſt pains in their roads; the labour and expence they were at to render them ſpacious, ſtraight, ſmooth, and agreeable, to the very extremities of their empire, are incredible.

Uſually, they ſtrengthened the ground by ramming it, laying it with flints, pebbles, or ſand; ſometimes by a lining of maſonry, rubbiſh, bricks, potſhreds, &c. bound together with mortar.

F. Meneſtrier obſerves, that in ſome places in the Lyonnois he has found huge cluſters of flints cemented with lime, reaching ten or twelve feet deep, and making a maſs as hard and compact as marble itſelf; and which, after reſiſting the injuries of time for ſixteen hundred years, is ſtill ſcarcely penetrable by all the force of hammers, mattocks, &c. and yet the flints it conſiſts of are not bigger than eggs.

Sometimes they even paved their roads, regularly, with large ſquare free-ſtones: ſuch are the Appian and Flaminian ways, &c.

The roads paved of very hard ſtones, they uſually called *via ferrea*, either becauſe they reſembled iron, or becauſe they reſiſted the iron of the horſes feet, chariots, &c.

Roads are either *natural* or *artificial*, *terreſtrial* or *aquatic*, *public* or *private*.

Road, *Natural*, is that which has been frequented for a long ſucceſſion of time, and ſubſiſts with little expence by reaſon of its diſpoſition, &c.

Road, *Artificial*, is that made by labour of the hand, either of earth or maſonry; and in the making of which, ſeveral difficulties were to be ſurmounted; ſuch are moſt of thoſe along the banks of rivers, and through marſhes, lakes, &c.

Roads, *Terreſtrial* or *Land*, are not only thoſe made upon the ground, but alſo thoſe formed of earth heaped up in manner of a bank, and ſuſtained by ſpurs, buttreſſes, and counterforts.

Road, *Aquatic*, is a road made in the waters, whether current, as thoſe of rivers, &c. or ſtagnant, as banks and cauſeways, or over moraſſes, &c.

Under this denomination are alſo comprehended navigable rivers, and artificial canals. See Canal.

Road, *Public*, or *grand road*, is any common road, whether ſtraight or acroſs, military or royal, &c. *Private* road is that made for the convenience of ſome particular houſe, &c. See Highway.

Roads, *Military*, ſo called among the Romans, were grand roads appointed for the marching of their armies into the provinces of the empire, for the aſſiſtance of their allies, &c.

The principal of theſe roads, in England, are Watling-ſtreet, Ikenild-ſtreet, Foſs-way, and Erminage-ſtreet. See Way.

Roads, *Double*, among the Romans, were roads for carriages, having two pavements or cauſeways, the one for thoſe going one way; the other for thoſe returning the other, to prevent claſhing, ſtopping, and confuſion.

Theſe two ways were ſeparated from each other by a bank raiſed in the middle, paved with bricks, for the convenience of foot people, with borders and mounting ſtones from ſpace to ſpace, and military columns to mark the diſtance. Such was the road from Rome to Oſtia, called *Via Portuenſis*.

Road, *Subterraneous*, is that dug in a rock with a chiſſel, and left vaulted. Such is that of Puzzuoli, near Naples, which is near half a league long; and is fifteen feet broad, and as many high.

Strabo ſays, it was made by one Cocceius, a relation probably of Nerva; but it has ſince been widened by Alphonſus, king of Arragon and Naples, and made ſtraight by the viceroys. There is another of the ſame kind in the ſame kingdom, between Baiæ and Cumæ, called the Grotto of Virgil, becauſe mentioned by that poet in the ſixth book of his Æneid.

Road, in *Rural Economy*, a track or way conſtructed with ſome ſort of hard materials for the purpoſe of travelling upon, with carriages, horſes, and other animals. Roads are of different kinds, as public and private, or parochial. The firſt ſort may be ſubdivided into toll and free-roads, and the latter into lanes or bye-roads: there are likewiſe other ſorts of roads, as carriage and horſe tracks, &c. It has been remarked by a writer, in the firſt volume of "Communications to the Board of Agriculture," that the conveniencies and beneficial conſequences which reſult from a free and eaſy communication between different parts of a county and diſtrict are ſo various, and the advantages of them ſo generally and extenſively felt by every deſcription of individuals, from the higheſt to the loweſt; that no labour or expence ſhould be ſpared in providing them; as, without ſuch ready means of intercourſe, all ſorts of internal commerce and improvement are either much embarraſſed, or wholly at a ſtand. And it is, indeed, well added, that roads and canals, or navigable rivers, may juſtly be conſidered as the veins and arteries through which all improvements flow. To internal commerce and agri-

culture, they are as the veins and arteries to the human body. Through these the blood circulates in every direction, and thus keeps alive the animal system; but, if this circulation is by any means checked or obstructed, even in the remotest part, that part soon becomes useless, and sinks into decay, and in some degree is felt throughout the whole body. So it is with respect to the commercial and agricultural systems. Without a free and uninterrupted intercourse, it is impossible they can exist, or at least produce, to the community at large, so many important benefits as they otherwise might have done. How many, for example, are the places, in almost every country, that might be rendered doubly valuable, if the access were practicable and easy. How immense the quantities of the finest timber, perhaps growing in inaccessible woods, which, on that account alone, are lost to society. How many the valuable strata of the richest metals and minerals, which, from the same cause, lie buried and undisturbed in the bowels of the earth; and how many thousands of acres of the most fertile soil, that might be improved and cultivated to the highest degree of perfection, and thus very largely contribute to increase the food and the comforts of man, were the ingress and egress rendered practicable and free. And the value of a farm, consequently the riches, perhaps the strength of a country, greatly depend on an easy and uninterrupted communication by good roads.

And the able author of the "Wealth of Nations" has well suggested, that good roads, canals, and navigable rivers, by diminishing the expence of carriage, put the remote parts of the country more nearly upon a level with those in the neighbourhood of the town. They are, upon that account, the greatest of all improvements. They encourage the cultivation of the remote, which must always be the most extensive circle of the country. Though they introduce some rival commodities into the old markets, they open many new markets to its produce. It is even further observed, that the Romans were so sensible of this, that we are told, the first writer says, they did not think it beneath the dignity of the commonwealth to attend to the conveniencies from good roads. That great and wise people, it is said, carried on, at an immense expence, roads, whose remains are to this day the admiration of the curious, from the centre of the empire to many of the remoter provinces. The readier march of their armies was, perhaps, he thinks, their first motive; but the easier intercourse of the several parts of the great empire was another, which they had too much prudence and too much wisdom to overlook. We are also told by Diodorus, Strabo, and other historians, he says, that the famous Semiramis, being so fully convinced of the importance of an easy and general intercourse, applied herself to render the roads practicable throughout the whole extent of her empire.

Mr. Donaldson also states, that, in an agricultural view, the benefits derived from good roads are incalculable. Before the establishment of turnpike roads in England, many parts of that kingdom, like the highlands of Scotland, were scarcely accessible. Coal, manure, grain, &c. as is still the case in many parts of Cornwall, were carried on horses' backs. Where waggons were used, seven or eight horses were necessary to draw about two tons, and seldom were able to proceed above twenty miles in a day. Now, where turnpikes are established, or other means used for keeping the roads in a proper state of repair, the same number of horses will draw at least five tons, and travel nearly double the distance, with much more ease. How absurd, then, continues he, for any person to scruple the payment of an inconsiderable toll, when the saving is so great and so evident; where the tear and wear in one case are not one-twentieth part of what they are in the other!

It is likewise contended by Mr. Beatson, in respect to the turnpike laws in this country, that they are liable to many exceptions; for although immense sums of money are annually levied for the purpose of making and repairing the highways, yet, either from bad management, from party influence, or from the chicanery and ignorance of surveyors and contractors, the roads in many places are not only laid out in the most absurd direction, but are so badly constructed, and kept in so wretched a state of repair, that they are almost impassable. It is surprising that in so enlightened a country, and where the turnpike laws have so much engaged the attention of many very ingenious men, those laws should still remain so very defective; more especially as there is hardly a country gentleman who attends a turnpike meeting, but considers himself completely master of the whole business and management, as well as of the making of roads; at least, if we may judge from the violent disputations and bickerings that frequently happen at these meetings, where a proposed new line of road, or perhaps the repair of an old one, will sometimes be contested with as great keenness and vehemence, as if the parties were contending whether Great Britain shall be a monarchy or a republic. And it is contended, that it too often happens party influence rules the proceedings at such meetings, and that those who are entrusted with the management of this business, delegate their powers, and trust the inspection and whole management and direction of the roads to some ignorant or pretended surveyor; who, almost to a certainty, will impose upon them, especially if he is empowered to settle with contractors; and thus the business of the public, in one of its most important concerns, is either altogether neglected, or terminated according to the convenience of the strongest party, without any regard to the interests of the community at large. In support of this assertion, he has only to refer to many parts of the principal thoroughfares in Britain. In some, it will be observed, the roads are directed in the most irregular zigzag manner, through a level part of the country, where they ought evidently to have gone straight forward. In other places, the traveller and the public, and the poor overloaded horse, are obliged to submit to all the inconvenience, the labour, and the fatigue of ascending and descending the steepest hills, when they might have gone, with the greatest ease and comfort, on a level road, by proper attention in the first making and laying them out. He is, however, far from thinking it would either be just or proper to force a road unnecessarily through any part of a gentleman's property without his consent, unless for very powerful reasons indeed.

If to avoid a deep ascent, or to shorten the distance considerably, and that there is no other way to do so, in that case there should be no hesitation; but if the advantages to the public are not very material, and that another line can be adopted, nearly as good, which will do less injury to an individual, the latter line should unquestionably be preferred in all such cases of laying out roads.

It should be a general maxim, he thinks, that private considerations ought, in all cases, to give way to public convenience and advantage. Society, says he, is formed for the mutual and general benefit of the whole, and it would be a very unjust measure to incommode the whole, merely for the convenience, or perhaps to gratify the whim or caprice of an individual. However, the property of an individual ought by no means to be taken to serve the

public, without allowing him, not only the full value, but more than the value proportioned to the inconvenience or injury he may sustain by the measure.

But he contends, farther, that while the present turnpike laws remain in force, and the common mode is practised of choosing surveyors annually, or by rotation, without the smallest regard to abilities or experience, it cannot be expected the public convenience will be so much attended to as it ought to be; neither is it to be expected, that the generality of surveyors, so chosen, can know the proper directions to give in making or repairing roads, nor the proper manner of making estimates, so as either to conclude an agreement with an artful contractor, or to form a correct judgment of such proposals as may be made. From these disadvantages, it is inconceivable the loss that may be occasioned, or the mischief that may be done by an ignorant and inexperienced surveyor. For he is decidedly of opinion that a surveyor of roads should be a man of considerable abilities, and of the strictest honour and integrity. A man not apt to be swayed by party influence, or by private or personal considerations; for if he once allows himself to be led away or biassed by those, or to act in any manner inconsistent with the public interests, he is unfit for that office. He ought not to be a man, who has all his life-time been confined to the narrow limits of a single district or county, or who has suddenly, or by a slender recommendation, been brought forward as a person qualified for so arduous an undertaking. He ought to have seen, in various places, the different systems adopted in the management and construction of roads, and to have made it a particular object of his attention, the judging of the best and most advantageous practices, under the particular circumstances of different cases. And besides these, there is another probable reason why, under the present system, the public roads cannot be so impartially managed and conducted as they ought to be, in the unlimited power given to country gentlemen over the roads in the county or district in which they live. Many of those gentlemen, for their benevolence and liberality, are truly deserving of every praise that can be bestowed upon them; but, however honourable and respectable they may be, and however desirous to promote the public good, it would be doing an injustice to human nature to suppose they can view, with impartial eyes, the fine plantations, the beautiful inclosures, and other improvements, they have made on their estates. We may as well imagine, that a doting mother can coolly and deliberately see an incision made in the skin of her darling child, however much it may be benefited by the operation, as that a country gentleman can with indifference behold a turnpike road carried through an inclosure, which he himself has been at the pains and the expence of adorning. He adds, that so situated, it is natural to believe this gentleman would wish that road to go in any other direction, even though it should not be quite so convenient to the public. He will not only use his own persuasion and endeavours to point out arguments against its coming that way, but he will even endeavour to prevail on his friends to exert themselves also, and thus a party is often formed in opposition to the public interest; and if he is a man of opulence and power, and generally respected, it is more than probable his influence will prevail in this business.

It consequently appears to him necessary, in order to obviate these abuses and inconveniencies, that there should be a controlling power over the measures proposed by country gentlemen respecting turnpike roads: for to allow those gentlemen to decide ultimately on the laying out a new road through their own lands, or even on the distribution of the money to be expended in repairing old roads, is, in fact, making them judges in their own cause. In short, it is an object so truly important to the interests of the community at large, and of the kingdom in general, to procure the most easy, safe, and expeditious, and the least expensive intercourse with every part, by means of the best roads, that it is a measure, he presumes, highly deserving the attention of the legislature; and which, from the great extent of business, would probably require a board, with proper surveyors appointed by it, for the purpose. If some plan of this nature were adopted, we should then hear no more of those numerous complaints that are so often made respecting the abuses committed in the management of turnpike roads, and of the money levied at the toll-bars, at many of which, it is said, by the author of the "Wealth of Nations," the money levied is more than double of what is necessary for executing, in the completest manner, the work which is often executed in a very slovenly manner, and sometimes not executed at all.

But in respect to the improvement of both the public and private roads, the following hints have been thrown out in the able Agricultural Survey of Shropshire. In lieu of surveyors in each parish (who are generally chosen in turn, and consequently have neither time nor experience sufficient to act properly, and are generally not inclined to exert themselves by enforcing the duty, &c.), the writer would propose for the magistrates to have power to appoint a proper surveyor with a salary, who should act under their direction, and be amenable to them for his conduct; such surveyor to undertake the arrangement of a certain district (say ten miles square), whose duty it should be to employ deputies, to call in and see the statute duty done under his direction: by this means the forming of the roads, which is the first principle, would be done in the most approved method, and the statute duty regularly called out. There may be an inspector, an inhabitant in each parish, appointed, and chosen yearly, whose interest it would be, as well as his duty, to act as a check upon the general surveyor and his deputy: this office, being easy, might be filled by one of the most liberal persons in the parish. He apprehends that an arrangement of this sort would very soon insure good private roads. And something like the following would, he thinks, procure good turnpike roads also; namely, the trustees of all the turnpike roads throughout England, to be obliged to erect weighing engines at all their gates or bars, at which tolls are received, on or before the 24th day of June next, the expence of such erections to be repaid to them, by their being empowered to add to their present respective tolls any sum to be paid by such carriage to be weighed, not exceeding so much as has been heretofore paid within one year last for the tolls; such sums to be paid, until all expence of erecting the said engines shall be fully repaid. The account of such repayment to be made out and settled by the clerks and gate-keepers belonging to the respective roads, and to be attested upon oath before two justices of the peace. And from and after the said 24th day of June next, it may be lawful for all carriages to be drawn with any number of horses along any turnpike road. But to prevent the injuries done to roads, by the great burdens too frequently drawn along them, it should be enacted, that from and after the said 24th day of June, it should be lawful for all trustees appointed by any act or acts of parliament, for the repair of any turnpike road, or any five or more of them, and they should be required at a public meeting, to be held

for that purpose on or before the 24th day of April next, to order to be erected at all the gates and bars which they have erected, or shall erect, for the receiving of tolls, or upon any part of the road within their respective jurisdictions, and at such a distance from any turnpike, bar, or toll-gate, as they shall think requisite and expedient to order and cause to be erected, a crane, machine, or engine, proper for the weighing of carts, waggons, or carriages conveying any goods or merchandize whatever; and by a writing signed by them, or any five or more of them, to order all and every such carriage or carriages which shall pass loaded through any such gate or bar, to be weighed, together with the loading thereof; and for them, or any five or more of them, or for any person or persons empowered by any five or more of them, to receive and take, over and above the tolls already granted, or hereafter to be granted, the sum of 10*s.* for every hundred weight, 112lbs. to the hundred, which every waggon or cart hereafter described, together with the loading thereof, shall weigh over and above the weights hereafter allowed to them respectively; that is to say, to every waggon or four-wheel carriage, having the fellies or rollers of the wheels of the breadth of sixteen inches, eight tons in summer, and seven in winter: to every waggon or wain, having the axle-trees thereof of such different lengths, that the distance from wheel to wheel of the nearer pair of the said wheels be not more than four feet two inches, to be measured at the ground, and that the distance from wheel to wheel of the other pair thereof be such, that the fore and hind wheels of such waggons and wains shall roll only one single surface or path of sixteen inches wide at the least, on each side of the said waggons or wains, and having the fellies thereof of the breadth of nine inches from side to side at the bottom or sole thereof, six tons ten cwt. in summer, and six tons in winter: to every waggon or four-wheel carriage, having the sole or bottom of the fellies of the wheels of the breadth of nine inches, six tons in summer, and five tons ten cwt. in winter: to every cart, having the fellies of the same dimensions, three tons in summer, and two tons fifteen cwt. in winter: to every waggon, having the sole or bottom of the fellies of the wheels of the breadth of six inches, four tons five cwt. in summer, and three tons fifteen cwt. in winter: and to every such waggon, so constructed as to roll, and actually rolling a surface of eleven inches by the wheels thereof, five tons ten cwt. in summer, and five tons in winter: to every cart having the fellies of the same dimensions, two tons twelve cwt. in summer, and two tons seven cwt. in winter: to every waggon, having the sole or bottom of the fellies of the wheels of less breadth than six inches, three tons fifteen cwt. in summer, and three tons twelve cwt. in winter: and to every cart, having the fellies of the same dimensions, one ton fifteen cwt. in summer, and one ton to twelve cwt. in winter. And if such trustees as aforesaid shall neglect to erect such engine at their respective gates by the said 24th day of June, then it shall and may be lawful for any mortgagee or mortgagees of the said gate or gates to erect such engine or engines, and to take upon them the same power as the said trustees were by the act invested with, and under the same regulations, on or before the 29th day of September next; and if the said trustees and mortgagees shall neglect to erect such engine or engines by the respective times hereinbefore stipulated for erecting the same, then it shall and may be lawful for all horses, carts, and other carriages, from and after the said 29th day of September next, to go through and pass along such road or roads, without any obstruction or payment for tolls whatsoever, until such trustees or mortgagees shall erect such weighing engine or engines as aforesaid, and occasion the same to be regularly used; any thing contained within the respective acts for turnpike roads to the contrary notwithstanding.

And it is usefully remarked, in respect to the effects of these regulations, that, first, the weighing engines will sufficiently prevent carriages of all sorts being overloaded, which will be a preservation of the road, whereas, the restraint upon the number of horses does not answer the purpose; for a short and overpowered team does more damage to the roads, than a greater number of horses, which draw easy, and consequently pass along much quicker. That disagreeable restraint will be thereby made unnecessary, which empowers and encourages some poor indolent wretches to wander about the country with their ready printed notices, to catch a prey, which, when got, is lavished away in drunkenness, debauchery, and disorder; and if they fail in their lawful attempt, which is often the case, and perhaps distressed to the greatest degree, being despised by persons of all denominations, pursue poaching and fowl-stealing, which lead to greater acts of thievery, of which there are many instances; for all the convictions are grounded upon the poor wretches as above described, being by the law allowed to be credible witnesses, who obtain the reward to the amount of 5*l.* or more, when the team-owner's servant or servants are all deemed prejudiced; so that, as the act now stands, no one is safe from these convictions.

Besides, the occupiers of farms in general, particularly those upon the middling-sized ones, find themselves, it is said, very much oppressed and injured by the law now subsisting for regulating the turnpike roads, by their being restrained from drawing more than four horses in waggons, the fellies of the wheels thereof being under six inches broad. Were farmers permitted to draw any number of horses, it would be of great public utility in lowering the price of those animals, which is now enormously high; the farmer would find it his interest, as formerly, to keep breeding mares, which, with the colts they breed, may be made useful great part of the year, provided they may be worked easy. The law, as it now stands, acts nearly as a prohibition to farmers breeding horses; for a breeding mare, or a colt under five years old, is not fit to draw one of four in a waggon, with no more than sixty bushels of barley or wheat, which is the common load of the Shropshire or Staffordshire farmers, neither of which bring more than two tons, which is considerably under the weight the present act allows to be drawn on the turnpike roads in winter. Before the said turnpike laws were in force, the farmer's team, to draw his sixty bushels of wheat or barley, consisted of six in number, two of which at least were mares, either in foal or sucklers, two colts, one of them two, the other three years old, which were never oppressed or hurt by their work; consequently a succession came on, and the owner had one or two good sound colts to sell off every year to the harness or draft, as they best suited. Good waggon horses were then bought at from 10*l.* to 15*l.* each, which are now, by their scarcity, from 25*l.* to 35*l.*; and those for the coach, that is, the light active half-blood horses, are from 40*l.* to 60*l.*

And another evil occasioned by this law is, that such farmers are obliged to keep horses of the largest size, which consume the produce of much land, by eating a large quantity of corn, when the smaller horses, working easy, seldom eat any. It is conceived by the same writer, that upon this principle, a law for regulating roads may be enacted, so as to answer every good design of the present, and at the

ſame time relieve thoſe individuals who are exceedingly injured, and alſo be of general utility.

It is likewiſe remarked in regard to private roads, that they are by no means properly attended to; and which may be attributed to the general highway act being ſo eaſy of evaſion, that every farmer is able to avoid doing ſtatute duty, or at leaſt next to none. Nothing is more valuable than *time*, eſpecially to a man of buſineſs; and a farmer who executes the office of ſurveyor of the highway, *impartially and effectually*, will find he muſt neglect no ſmall part of his own buſineſs; and after all he might, perhaps, have been as little out of pocket had he done the whole work with his own team and labourers. It is ſtated, that there is no trick, evaſion, or idleneſs, that ſhall be deemed too mean to avoid working on the road; ſometimes the worſt horſes are ſent, at others a broken cart, and a boy, or an old man paſt labour, to fill; they are ſometimes ſent an hour or two too late in the morning, or they leave off much ſooner than the proper time, unleſs the ſurveyor watch the whole day. It is true, that redreſs may be had by application to a magiſtrate; but then how often cauſes of complaint occur; and how many days muſt be loſt to bring each home to the offender; who, *from cuſtom*, thinks he is doing no harm; beſides the conſtant breach of good neighbourhood that muſt be occaſioned by theſe petty litigations. It is ſuggeſted that a remedy might eaſily be had in the following manner. Aboliſh all perſonal ſervice upon the highways. Let ſurveyors be appointed, as at preſent, who ſhould have power, under the authority of two magiſtrates, to raiſe, by rate, certain ſums that may be neceſſary for the repair of the roads within the reſpective pariſhes and townſhips, and to account for the ſame at going out of office at the year's end. The farmer, who acts as ſurveyor, might then be able to repair the highways when moſt convenient to himſelf, and when he could give attention to them without any interruption or impediment, whereas at preſent ſome duty is given up, or nearly ſo, from the difficulties ariſing in collecting it. On the ſame principles, the author of the Preſent State of Huſbandry in Great Britain contends, that an act of parliament ſhould be introduced, for the purpoſe of reſcinding the ancient laws reſpecting ſtatute labour; which have in every inſtance been found ineffectual, and to eſtabliſh other general rules and regulations more likely to anſwer the purpoſe in the new improved ſtate of the country. He adds, that the exiſting acts of parliament reſpecting the making and repairing roads, where the juſtices of the peace cannot commute the ſtatute labour, are not ſufficient for the purpoſe of raiſing a fund ſufficient for keeping the roads in repair. Where the juſtices of peace have it in their power to aſſeſs the inhabitants in a ſum of money in lieu of the ſtatute labour, it is in general not the want of means, but the miſapplication of that means, or negligence in the general management, that is the cauſe why the pariſh roads are almoſt every where a diſgrace to the country. The imperfect and indifferent modes of executing the ſtatute work, as ſtated above, render it neceſſary, it is ſuppoſed, that thoſe ſtatutes enforcing the performance of this neceſſary duty ſhould therefore be aboliſhed; and in every county the juſtices of the peace ought to be inveſted with the power to aſſeſs the inhabitants of the diſtrict by ſome equitable *ratio*, whereby they would pay only in proportion to the benefit they received. Were this generally done, as is the caſe in ſeveral parts of Scotland, the counties divided into diſtricts of ſuch ſize, that the proprietors could conveniently meet as occaſion required; the money ariſing from the commutation act collected by one perſon, who ſhould be allowed a certain *per centage* on the ſum collected, be continued during good behaviour, and be reſponſible for his conduct to the gentlemen of the diſtrict; the money ſo collected be afterwards expended under the direction of theſe gentlemen, and the whole be ſubject to the review of the quarter-ſeſſions; the pariſh roads would, it is ſuppoſed, ſoon be materially improved. If to theſe regulations a power were added to mortgage the ſum ariſing from the commutation of the ſtatute labour for ſuch a number of years, and to ſuch an extent, as was found neceſſary to put the uſeful private roads in a perfect ſtate of repair, they might, it is ſuppoſed, in a few years, be made the reverſe of what they are at preſent. The laſt meaſure would be found the moſt effectual of any that could be adopted, and is probably the only one that can be reſorted to for the purpoſe of effecting an immediate and general improvement.

It has likewiſe been remarked by the author of the "Landed Property of England," in reſpect to the improvement of farm-lands by theſe means, that the art of planning, forming, and repairing roads, is a ſubject with which, for various reaſons, every manager of a large eſtate ought to be familiarly converſant. It is not enough for him to know the theory, or general principles, of the art. It is neceſſary that he ſhould ſtudy it practically in the particular diſtrict in which he is placed; and with the given materials that it happens to afford; as by theſe means he can only be capable of executing the buſineſs with the greateſt poſſible advantage. In this buſineſs a moſt material point, whether in the *laying* out of *new* roads, or *improving* ſuch as have been long eſtabliſhed, is that of giving them all the advantage in direction and other circumſtances that the peculiarity of their nature and ſituation admit of. It has been ſtated by the above writer, that moſt of all the old roads of the kingdom (the remains of the Roman ways excepted) owe their preſent lines to fortuitous circumſtances. Many of them were, no doubt, he thinks, originally foot-paths; ſome of them, perhaps, the tracks of the aboriginal inhabitants, the patriarchal ſavages, who lived by hunting; or of the paſtoral tribes, who travelled with their flocks and herds from paſture to paſture, as herbage and browze invited; or of the firſt ſettlers, between biding places which may not now exiſt. And that theſe incidental foot-tracks, eſpecially when they led through woods, became, as the condition of ſociety advanced, the moſt convenient horſe-paths; as we not unfrequently find at the preſent day. Conſequently, that in this ſtate of ſociety, before wheel-carriages were in uſe, many of the lands of the kingdom were appropriated, by which circumſtance thoſe fortuitous lines of roads became fixed and unalterable; there being no other legal lines left for carriage roads, than thoſe incidental horſe-ways, or ſmall tracks. He ſuppoſes, that in this account of the probable origin of roads, we have, at leaſt in part, the cauſe of the crookedneſs, as well as the ſteepneſs, of carriage roads, between the places which are now inhabited: for true it is, that the traveller is not unfrequently led down one ſteep to make an angle, and aſcend another; while the hang of the hill would conduct him nearly on a level, and by a more direct line. But, admitting that a cluſter of habitations heretofore ſtood at the angle, the ſeeming abſurdity ceaſes. He adds, that formerly, it is probable, the zigzag direction of roads, between towns and villages, was much more obſervable than at preſent. In more modern times, and ſince the legiſlature wiſely interfered with reſpect to appropriated lands, many improvements of lines have been made. And, by the general laws which have more recently been paſſed, magiſtrates are inveſted with authority to alter eſtabliſhed lines. So

that now, the expence of alteration may be said to be the only obstacle, in ordinary cases, to the perfection of the lines of roads in this country. And which is, of course, a circumstance that has had much effect in improving the convenience of travelling.

And it is suggested, in respect to the direction of roads, that the most perfect line is that which is straight and level. But this is to be drawn in a country only which is perfectly flat, and where no obstructions lie in the way:—joint circumstances that rarely happen. Where the face of the country, between two points or places to be connected by a road, is nearly but not quite level, by reason of gentle swells that rise between them, a straight line may be perfect;—may be the most eligible under these circumstances. But where the intervening country is broken into hill and dale, or if one ridge of hill only intervenes, a straight line of carriage road is seldom compatible with perfection. And that in this case, which is nearly general, the best skill of the surveyor lies in tracing the midway between the straight and the level line. Here the level line of perfection, for agricultural purposes, is to be calculated, by the *time* and *exertion* jointly considered, which are required to convey a given burden with a given power of draft from station to station. On great public roads, where *expedition* is a principal object, time alone may be taken as a good criterion. It is likewise added, that the most regular method of finding out the true line of road, between two stations, where a blank is given,—where there is no other obstruction than what the surface of the ground to be got over presents,—is to ascertain and mark, at proper distances, the *straight line;* which is the only certain guide to the surveyor. And that where the straight line is found to be ineligible, each mark becomes a rallying point, in searching on either side of it for a better. If two lines of equal facility, and nearly of equal distance from the straight lines, present themselves, accurate measurements are to determine the choice. If one of the two best lines, which the intervening country affords, is found to be easier, the other shorter, the ascent and the distance are to be jointly considered, the exertion and the time required are likewise to be duly weighed. Further, also, the nature of the ground, the source of materials and, generally, the comparative *expence* of forming the road by two doubtful lines, as well as their comparative *exposure*, are to be taken into consideration. A long line of road, across a broken country, should not be hastily drawn or determined upon by the directors of this sort of business.

But in regard to the most difficult and troublesome part of this sort of work,—the necessary management in the ascent of hills,—it is observed that, whether in laying out a fresh line, or in altering an established one, modern road surveyors, like many other reformers, have run from one extreme to another. To do away the absurdity of going up one steep and down another, to ascend a third in order to reach the required elevation (a common occurrence on fortuitous roads), they have ingeniously, but very injudiciously, given an uniform rise from the bottom to the top of the ascent. In the theory of mechanics, and where mechanic powers only were to be used, a regularly inclining plane would be perfectly proper, in a case of this kind. Where the requisite power is to be applied by rational beings, the same principle, though not altogether perfect, may be allowed; but when the moving power is neither purely mechanical, nor in a sufficient degree rational, but an irregular compound of these two qualities, the nature and habits of this power require, he thinks, to be consulted. It is, he conceives, one of many instances, which shew the impropriety of applying purely mechanical principles, in agriculture and rural concerns, in which they are to be combined, not only with the power but the will of the animals. No man who has been accustomed to drive a road team, or in the habit of seeing one driven in a hilly country, and who properly regards what he sees, would lay out a long line of ascent without one or more breaks, or convenient resting-places; in which the animals of draft may relax at their ease, and set off again without difficulty. He, however, observes, theory will readily suggest that, by a drag-staff, or pall, a carriage may be securely stopped on the steepest ascent. But practice well knows the danger of checking the efforts of beasts of draft while they are struggling against the collar. For if they possess any habits, or even the seeds of restiveness, nothing is, he contends, more likely to encourage, or produce it, than suffering them to stop under the difficulties of draft. Besides, those which are true to their work, well knowing the extraordinary difficulty to be overcome, in putting a carriage at rest into motion in such a situation, stop under a degree of anxiety; while the more spirited and irritable stand on the rack, and tremble at the apprehension of the painful effort they have to make. But let them see an end, or a respite, of their endeavours, and they will struggle with willingness. A rest, after the difficulty is surmounted, comes as a reward for their exertions. But where the natural surface of the ground is well studied in any given case, there will seldom, he supposes, be much difficulty in assigning the places proper for rests; so as to make the road not only easier for carriages of burden, but safer and more pleasant to travellers, as well as more sightly: besides being better to be kept in repair, than an uniform descent; by reason of the flatter stages being checks to the surface water, and convenient places to get rid of it, without injury to the face of the road. But where such breaks do not occur, the line of ascent should be uniform; or as nearly so as the natural surface, or immoveable obstructions of the acclivity to be surmounted, will allow in the particular case.

Likewise in the setting out of these lines, the common level is to be set by an observation from the bottom to the top of the ascent (these points having been previously determined on, by the given circumstances of the general line of the road), or from station to station where a clear view cannot be had between the extremities; and the degree of ascent, thus ascertained, is to be marked with a pencil upon the instrument that is made use of for the purpose. And by this mark it is advised to trace a rough line along the face of the hill; in order to determine, with sufficient truth, respecting the proper breaks, or resting-places, that may be required; endeavouring to fix upon such natural breaks in the slope as are situated in, or sufficiently near, the general line of ascent. And that when this has been done, to ascertain, by similar observations, the exact angle of elevation, or degree of steepness of each rise, or length of ascent between the breaks, &c. by these means procuring an unerring guide, in marking out and forming the base or bed of the road; without the risk of incurring unnecessary labour and expence in doing the work twice over to bring it to the truth, or a state of suitable exactness.

But it is well remarked by Mr. Marshall, that the best services of the road surveyor lie in avoiding, not in surmounting hills. And that in a long line of road, between places of nearly equal elevation, this may often be done. There are instances of the most public roads going over the tops of hills, where lines of equal length might be traced along their bases; and the difficulty and danger of ascending and descending the steeps be avoided by such means.

Very much attention has lately been bestowed on this de-

partment of the road-maker's bufinefs, efpecially in the more northern parts of the kingdom; but much is ftill left to be accomplifhed, efpecially in the weftern diftricts of the fouthern parts of the ifland, where an attachment ftill remains to the original lines or directions.

And it is fuggefted by Mr. Beatfon in the paper above alluded to, that the bufinefs of laying out the lines of roads may, in fact, be reduced to three fimple principles; thofe of fixing upon the *fhorteft*, the *moft level*, and the *cheapeft* directions, for which, though apparently very eafy of execution, from the frequent occurrence of circumftances that render it neceffary to deviate from them, the knowledge and experience of the furveyor are found requifite. The firft requifite from its being a ftraight line, is often neceffary to be departed from in order to avoid the removal of expenfive obftacles, fuch as hills, rocks, water, and moraffes. The fecond is of vaft importance, and fhould invariably be adhered to, if poffible, even though the other two fhould, in a certain degree, be given up; for it is infinitely better to go a confiderable way about to obtain a level road, than to go ftraight forward and be obliged to take an afcent; but it may, in fome cafes, be preferable to afcend a gentle rife, in order to obtain a good hard bottom, and a road eafily made, than to go on a level through a fwamp, or piece of water, which would require a much greater quantity of materials, be much more difficult to keep in repair, and occafion a great deal more expence. It is not the moft hilly line to appearance that is always to be rejected as being the leaft level; for the fteeper and fhorter fome hills are, it will be the eafier to obtain a level road in that direction, by cutting down the fummits, and laying the materials taken from them in the vallies or hollow parts, which, in many inftances, may be done with great facility. And the third, or the leaft expenfive line, is alfo frequently given up, in order to obtain one or both of the other two. It is therefore concluded, that much depends on the fkill and ability of the furveyor, who, before he finally determines on a line of road, ought to make himfelf perfectly mafter of every part of the intermediate and adjacent country; nor fhould he rafhly determine at once, but fhould examine repeatedly, over and over again, whether no other line would be better than that he firft thought of.

And with refpect to the parts or divifions of which a public road fhould confift, it is obvious that they fhould vary in fome meafure, according to the nature of the traffic or bufinefs which is carried on upon them, the fituation in which they are placed, and the particular circumftances of the different cafes. It is, however, contended by the author of the "Landed Property of England," that the plan and formation of all *public* roads fhould be the fame; every public lane, or other fcite of a public road, he conceives, ought, where the width and other circumftances will permit, to be divided into three travellable lines, namely: 1. A middle road of hard materials, for carriages and horfes, in winter and wet feafons: 2. A foft road, formed with the natural materials of the fcite, to be ufed in dry weather, to fave the unneceffary wear of the hard road, and to favour the feet of travelling animals; as well as for the fafety, eafe, and pleafantnefs of travelling in the fummer feafon: and 3. A commodious path, for the ufe of foot paffengers, at all feafons. But in thefe cafes, he thinks, modern practice has fimplified too much. Inftead of thefe three requifites of a public road, we generally find a parliamentary or turnpike road (away from the environs of great towns), confifting, fimply, of one uniform broadway of hard materials; upon which horfes ftumble, and carriages jolt, the year round: while travellers on foot are feen wading to their ankles in mud, or in duft, according to the ftate of the wind and weather. His notion of what the nature of a public road ought to be, is, that within the fences of a lane or road there fhould be a raifed foot-path, a convex hard road, a foft fummer road, and channels to carry off the water collected by the carriage roads; the foot-path being cut acrofs, in proper places, to permit the water, which falls on that fide of the middle road, to pafs off freely into the ditch at that fide, as well as to prevent horfemen from riding along the path; the oppofite hedge-bank being perforated, to let off, into the other drain on the contrary fide, the waters which may collect on that fide of the lane or road.

And in regard to *private* roads it is contended, that where they are much ufed, as in fuch as lead from a village or other place to a public road, they fhould have a double carriage path, fo that carriages may any where pafs each other. But that for fuch as lead merely to a farm-houfe or a hamlet, a fingle line fufficiently wide to let a fingle or faddle horfe pafs a carriage with occafional dilations for carriages to pafs in, are only in general requifite.

Form of Roads.—Further, in regard to the moft appropriate form of roads, there has been a great difference of opinion among the perfons engaged in this fort of work, fome contending in favour of the *convex* form, while others are inclined to think the *concave* fhape preferrable in many cafes; and ftill others, that they fhould be either made perfectly flat from one fide to the other, with inclined planes longitudinally, or be *wholly flat* in every direction. But experience fully fhews, that fome degree of the convex form is neceffary in almoft every cafe, in order that the wetnefs and moifture may be difcharged with greater facility, and of courfe the roads be preferved in a more dry ftate. And in fpeaking of this form of road, Mr. Beatfon obferves, that the rife in the middle is more or lefs according to the fancy or whim of the makers, but in general it is a great deal too much. This form is adopted on the idea, that whatever wet falls upon the road will run off towards the fides into drains made there for the purpofe of receiving it. If the roads were a perfect fmooth hard furface, this theory would, no doubt, he thinks, hold good; but in practice it is found not to be the cafe, for the wheels of carriages occafion fo many ruts, and fuch a roughnefs on the furface of the roads in general, that little or no water can run towards the fide-drains, however convex the road may be. It confequently lodges in thofe ruts, and every fucceeding carriage, he thinks, the more eafily makes them deeper, and works the water and materials together in fuch a manner, as very foon to render the road extremely difagreeable. This frequently happens, he afferts, even on roads that have been made moft incommodioufly convex, for the very purpofe of keeping them dry; confequently, the convexity of a road has not the defired effect of preventing water lodging upon the furface. Befides, it is, he conceives, extremely inconvenient for all wheel carriages, and deftructive to the road itfelf, by making the loading reft unequally upon the wheels, unlefs when going on the very middle of the road, for the loweft wheel will always bear the greateft part of the burden, and therefore will injure the road the more in proportion. If a cart or any carriage with two wheels is loaded, we will fuppofe, with two tons weight; when that cart is upon a level from fide to fide, the load is equally divided, and each wheel fuftains the weight of one ton; but if that cart is going on the fide of a convex road, there will perhaps be the weight of a ton and a half upon one wheel, and only half a ton upon the other, confequently the lower wheel, in this cafe, will do the road as much injury, as if the cart were loaded

with three tons upon a level, instead of two upon such a declivity. The proportion of weight upon each wheel, according to the declivity, will depend on the nature of the loading of the cart, for the higher the centre of gravity of the load is, the greater will that weight be on the lower wheel on the same declivity; and therefore a cart loaded with hay, straw, or wool, or any other bulky commodity, will be more injurious to a convex road, unless when on the middle of it, than the same cart loaded with the same weight of stone, lead, or iron, or any other weighty commodity which lies low in a cart: and nothing can be more injurious on such roads, than a stage-coach loaded with outside passengers. But the destructive consequences of allowing carriages to heel much on any sort of road are even visible, though in a small degree, he supposes, from the effect produced by a wheel going over a stone, or any hard substance lying in one of the tracks or ruts, in which case there will soon be a deep hole formed by the wheel in the other track, directly opposite to that stone or substance which raised the other wheel. Every precaution ought, therefore, to be used to prevent carriages heeling to one side on any part of a road. And he suggests, that the inconvenience, and in many cases the danger, of going on either side of a convex road, makes all waggoners, carters, coachmen, &c. keep always on the middle, by which, on such roads, there is seldom any other part used by wheel carriages, however wide the road may be; consequently, by the carriages being always confined to the same track, that part of the road soon gets out of repair, and requires a constant outlay of money to keep it in proper order or condition for being travelled upon. It is also added, that the method of forming and making the convex roads, in the first instance, appears to him very absurd. He supposes, that before any hard materials are laid on, the road is generally formed in somewhat a hollow manner, rounded below, in which there are drains, or ditches, on each side: also the footways or horse roads when made high enough. These are also sometimes called the summer roads, on account, he supposes, of that being the only season they can in general be travelled upon. The road forms a convex line, about ten or twelve inches lower at the sides of it than the footway and summer road. After being thus formed and prepared, the hard materials, mostly consisting of broken stones, are laid on, which, it is supposed, will fill up that space which is the hollow in a convex line, and when finished, the whole surface, from one side to the other, forms one convexity; the footways or horse roads being made a continuation of the same curve. And this is still with the idea, that all the water that falls on the road will run into the drains on each side. But let any person, in wet weather, take a view of a road thus formed, and he will find, that, in general, however great the convexity may be, the water will stand in every rut and every impression made upon it, especially if the road has been long travelled upon; that the stones on the surface are pulverized by heavy wheel carriages, and the wet earth from below worked up among them. Also where the road is but newly made or repaired, and the materials are sufficiently porous to let through the water, it will then lodge on the convex surface, in every impression of a stone or other uneven part, particularly at the sides, where it is dammed again by the footways, and thus the bed or foundation of the road is kept constantly moist, and of course it will very soon go out of repair. By this continual moisture the stones sink down into the soft earth, of which the bed of the road is composed, and this earth works up through the harder materials, and occasions all that dirtiness generally on the surface of roads in wet weather, although, perhaps, ten or twelve inches in thickness of those hard materials had been at first laid over it. Sometimes, indeed, there are under-drains made through the footway, from the side parts, at every ten or fifteen yards distance, to convey the water into the ditches; but even this is not found to answer the purpose intended, for the intermediate spaces soon become so impervious, that the water does not pass through them to enter these drains, the wet earth being converted into a sort of puddle, resembling what is used, in aquatic works, for the purpose of preventing the moisture from penetrating through, and consequently it lodges in all the ruts and hollows on the surface, without passing off so quickly as should always be the case in such instances.

Besides this there is another manner of forming these convex roads advised in the Bedfordshire Agricultural Report, in which it is proposed to leave a hollow or vacuum, as it is called, in the middle, to deposit the hard materials in. The only difference that appears to be between this and the method described above, is, that instead of the bottom of this hollow being made convex, it is made flat, and also deeper. It is thought that this method is liable to the same objection as the former, perhaps even in a stronger degree; besides, it would require a much greater thickness of hard materials, which are very expensive, and those materials would be deepest or thickest in the middle of the road, where the wheels of carriages hardly ever go, consequently that part is not so liable to be cut up as the tracks in which wheels most generally run, and produce their greatest effects. Mr. Marshall seems, however, to think more favourably of this form of road, especially for wet weather, assuming it as a sound position, that roads, in general, which are intended to be travelled in wet seasons, should be *convex* or *shelving*, not flat or concave. It remains to determine the proper degree of convexity of the hard line of road; from the margin of which the dry-weather line ought to shelve gently to the foot of the hedge-bank; so that carriages may pass freely, and safely, from one line to the other; and in order that the rain-water which falls on that side of the lane may find its way, easily, into the channel prepared for it, which is, he conceives, for a wet-weather road, to be regulated by a variety of circumstances: as, first, by the materials of which it is to be formed: soft materials are most liable to be worn into ruts and hollows, and require to be laid up with a quicker descent for rain water, than hard materials, which require less elevation or rotundity of surface; and least of all a firm even pavement. Secondly, that a convex road in the face of a steep is to be laid up higher, with a given material, than one on more level ground, on which rain-water has no other tendency than to the sides; whereas in the face of a steep, it it may have an equal or greater tendency along the line of road; and is liable to be caught by the slightest impressions of wheels; and thus to wear channels, as may too often be seen, from the top to the bottom of the hill. Even where the surface of the road is perfectly smooth, it may have twice the distance to run, before it reach the outer margin, that it has on a level. And thirdly, that the degree of convexity is to be determined, in part, by the width of the road; the materials and descent being equal. A wide road requires to be formed with greater sideway descent than a narrower one; which more readily frees itself from rain-water, inasmuch as the distance is shorter from the crown to the outskirts of the road in such instances.

But that the freeing of a road from rain-water is not the only object to be kept in view, with regard to its convexity: the ease and safety of carriages, and particularly those of burden, whose loads, being of light materials, are laid up high, require to be consulted. A carriage moves most freely, and with the least exertion of draft, when the load

lies evenly upon the wheels on either fide. In proportion as the weight is thrown on one fide or the other, the refiftance is increafed; efpecially on the road which is liable to impreffion. Hence the inconvenience of a highly convex road in the face of a fteep; and hence the utility of breaks in long afcents, or fuch roads as are formed in hilly fituations.

In fact, he conceives it evident in refpect to convexity, that every part of a road fhould be equally and duly convex, —fhould be equally fafe and eafy for carriages of every defcription; otherwife it becomes partially worn; the more level parts only are ufed; the fteeper being in a degree ufelefs. Hence a road of even and due convexity is not only eafy and fafe, but may be formed of a narrower width, than one whofe fteep fides are neither eafy nor fafe to be travelled; and whofe crown, only, is in ufe for paffing upon. And on meafuring different paffages of roads which appeared to lie in the moft defirable form, and taking their convexity, or the elevation of the crown or middle of the road above the bafe line, he has found that roads of twenty feet in width rife about ten inches: namely, one inch in every foot, on either fide. And he is of opinion that this refult may be taken as a general guide in forming roads: this middle degree of convexity being liable to be altered according to the width of the road, the nature of the materials, and other circumftances which have been ftated already.

And concerning the fecond or concave form of roads, Mr. Beatfon thinks that it is quite the reverfe of the common form, being loweft in the middle, where other roads are generally made higheft. By differing fo widely from the common practice, and the general opinion of road makers, one would at firft be almoft inclined to fuppofe, that fo fingular a practice in forming roads could only proceed from a defire or propenfity to differ from the reft of mankind: but when we are told that the late celebrated and ingenious Mr. Bakewell was an advocate for this form; that the road by his farm of Difhly, and that through Mefham, in the fame county, are both upon this principle, and in much better order than the roads found about them; likewife that the road through Bredon, made under the direction of Mr. Wilkes, is of the fame form, and is faid to be better now than ever remembered before, and kept in order at much lefs expence:—when we confider thefe well authenticated facts, fupported by fuch refpectable evidence, we naturally conclude that the reafons for adopting this uncommon form of road, are founded on fomething more fubftantial than mere whim and caprice; and confequently deferve to be more fully inveftigated. This writer ftates, that he has not been able to learn the manner of forming thefe kinds of roads before the hard materials are laid on, but, when completed, he underftands the form is fomething fimilar to that of a paved ftreet, with a drain for the water in the middle. The whole width of the road is divided into three equal parts, or nearly fo. The fides are made quite flat. The middle divifion has a gradual but fmall defcent, or concavity, from each fide to the middle part, which is the middle of the road. This concavity has alfo a fmall defcent lengthways, made on purpofe, if not declining naturally, fufficient to carry off the water to proper outlets. In the middle divifion the beft and hardeft materials are laid. The direction of Mr. Wilkes, as ftated in an ingenious paper, in the firft volume of Communications to the Board of Agriculture, is, that when the fall is one foot in 150 or 200 feet forward, the fall from the fides towards the middle ought to be 15 inches in 20 feet. When one foot in 100 to 150, to be 12 inches. One foot in 30 or lefs, to be even the whole breadth. Where the width of a road is 60 feet, one foot of fall to each 40 feet in length of the road. Twenty feet from the fides towards the middle, to have nine inches of fall.

The inner 20 feet to be flat.

And Mr. Bakewell's idea, he is informed, was, that water, where it can conveniently be applied, fhould frequently be let run upon this concave part, in order to wafh it quite clean; for it is always obferved, where a fmall ftream of water comes upon a road, that part, if the bottom is good, is generally firmeft, and hardly ever gives way. To have a command of water, therefore, to flood the road at pleafure, he thought would be of great advantage in keeping it in order. And the other ufeful properties attending a road of this form are the following: There are three parts of it on which wheel carriages may go, without heeling to either fide; on the fide divifions, and alfo on the middle divifion, when the horfes walk in the loweft part. This is certainly a material advantage, being much more eafy for the horfes and lefs injurious to the road. By carriages ufing indifcriminately thefe three tracks, all parts of the road will wear more equally and for a greater length of time; whereas in the convex roads, there being only one part, namely, the middle, on which carriages can go without heeling, that part only is moft generally ufed, and confequently fooneft gets out of repair, which is a great inconvenience in fuch roads.

With refpect to flat roads floping longitudinally, the advocates for them obferve with good reafon, that by being flat or level from fide to fide, the preffure of wheel carriages will be more equal, the friction lefs, and all parts of the road may be travelled on with the fame facility; confequently it will wear more equally, be eafier kept in repair, and require fewer materials for keeping it up. But notwithftanding fuch advantages are deferving of attention, it muft feem to thofe unaccuftomed to fuch a form of road, a difficult matter to keep it fufficiently dry, or free from the ftagnation of water upon it. But from its having been obferved that the ruts made by the wheels of carriages prevent the water running to the fides of convex roads, it is propofed that roads of this form fhould have in every level part gentle flopes, fufficient for water to run along, which, fuppofing them to be one foot in fifty, would hardly be perceptible. On thefe flopes, or inclined planes, the ruts made by the wheels of carriages would promote the water running off, by forming fo many little channels or conductors for it to run into the lower part of thefe flopes, from whence it muft be properly conveyed away. By this plan fuch roads will be much more eafily kept dry than the common roads ufually are or can be from the nature of their conftruction.

And farther, in regard to the wholly flat form of roads, the reafons given for them are nearly the fame as ftated in fupport of the laft, only that as there are few parts of a country fo perfectly level, for any confiderable diftance, that water will not run either one way or another, it is confequently unneceffary to be at the expence and trouble of forming thofe flopes or inclined planes recommended in the preceding form; but that proper outlets fhould always be kept clear at every hollow part, and if the road fhould in any place be quite level, a fhallow crofs drain, that will occafion no impediment to carriages at every 50 or 60 yards diftance, or nearer, will keep the road fufficiently dry.

And it is from thefe ftatements concluded by Mr. Beatfon, that the main objects fought after are, 1. To keep the road always as free from moifture as poffible: and 2. To conftruct it in fuch a manner, as to render the draft or communication eafieft, at the leaft expence. In thefe are

comprehended all the requisites necessary to form a complete road. To attain them in the best manner is therefore the important point. Four different methods have been stated, each of which has its supporters. The arguments in favour of each have also been shortly mentioned, which will shew that their main object is the same, unless perhaps the idea of watering the concave road may be considered a deviation from one part of the general rule: but as that is proposed to be done only to wash the road occasionally, in case it becomes dirty or slushy, it cannot therefore be considered in that light in any respect whatever. But from these modes of constructing roads being in some measure unsatisfactory, he is induced to offer a new theory on the subject, which is founded on the knowledge of the stratified nature of the earth. It is however only given as theory, having never, he believes, been subjected to the test of actual practice. It is observed, that every person who has paid the least attention to the structure and formation of the different strata of the earth, must have seen that some of these strata are of so close a texture as to be impenetrable to moisture; others again are so porous, that water will easily run through them in any direction, till it meets with some obstacle, or finds a vent. Of the first sort some are less dense, and of the latter some less porous than others, consequently as they partake more or less of these qualities, the water or moisture will the more or less quickly penetrate through them. But in order to shew this more clearly, and apply the principle to the construction of roads, he supposes the section of a hill or eminence composed of a number of strata. If the upper stratum or surface soil is of a porous nature, it is evident that any water which falls upon it, will penetrate through to the stratum below, where, if it cannot go farther, it will glide along the surface till it finds a vent at the bottom of the hill; if the second stratum is hollow, and continues on towards any depression in it, the water will lodge in that hollow, and form a sort of pool or bog, as is sometimes observed on the tops of hills; but if in this hollow place there is a communication with the porous stratum, no water will lodge there, but it will penetrate through and glide along the upper part of the dense stratum below, till it finds a vent on the side or at the bottom of the hill, as before. And by the above it will also appear, that if the uppermost stratum is of a close texture or clay, any water falling upon it will not only lodge in the large hollow, but in the smaller ones, and in all the other irregularities or concavities that may happen to be upon the surface. Hence, also, it is evident that in order to keep dry the surface of any such piece of ground, it matters not of what shape or form that surface is, or whether it is convex or flat, provided there is a communication with some under stratum, sufficiently porous to carry off the water below; but it is of some consequence the form of the upper part of that stratum upon which the water is to run, for the smoother it is, the water will of course the more easily flow away, and be discharged from it.

It is easy, it is supposed, to apply these principles in the forming of roads in the following way: when a new road is to be formed, let it be done in the first instance nearly in the usual manner, with such materials as are on the spot, and the nearer the quality of these approaches to *clay*, so much the better. Instead, however, of forming it convex, as is generally done, let the lines on either side from the middle be quite straight, and meet in an angle or ridge at that part or the middle of the road, having a slope from thence to each side, of about an inch in a foot. There are to be made small drains for the more easily conducting away the water that may be collected at those places. The road, being thus formed, must be allowed to harden and settle for some time before any other materials are laid on, great care being taken, while in that state, to let no carriages or cattle upon it, and it should be rolled with a long wooden roller, that will reach at once from each of the sides to the middle. This roller should be loaded with a box of stones to make it sufficiently heavy, and that it may be the more portable when that box is taken off; and it may be so contrived, that by changing the horses from one side to the other, there will be no occasion to turn the roller, in order to make it roll the same space over again. Being rolled in this manner, will consolidate the materials composing the ridge of road, and prepare it for receiving those to come afterwards, for it is a most absurd practice to lay hard materials in the common way upon this first form or basis of a road, before it is sufficiently firm to bear them. When thus formed and properly settled, the next step to be taken is to imitate the works of nature in dry soils as nearly as possible, by forming a stratum penetrable by water, composed either of sand or sandy gravel, or any other substance easiest to be got, that is sufficiently porous to admit water to pass through it. This stratum should be laid quite level, and extending from one side of the road to the other, filling up the small drains also on the sides. Over this are to be laid the best materials that can be got for completing the road, consisting either of stones broken very small, or of the best gravel. This coat of hard materials need not exceed above six or seven inches in thickness, which being much less than is commonly used, will be a considerable saving; and it may even still be less, if the directions hereafter given are strictly attended to. If this covering consists of broken stones, they should afterwards be laid over with sand or fine gravel, when easily procured, so as to fill up all the cavities betwixt them. The sand or rubbish from a freestone quarry is excellent for this purpose, providing there is no mixture of earth in it, which should be carefully guarded against in every step taken after the road is first formed. These finishing materials being properly laid on and smoothed with a rake, the whole should now, before any carriages or horses are admitted upon it, be well rolled with a heavy iron roller, divided in three parts for the purpose, the two hind divisions of the roller being large, the front or middle division smaller, to the framing of which the shafts are fixed, and so contrived, that it turns in the manner of the fore-wheels of a waggon; there is a box for holding stones to increase the weight when necessary; but in adding this weight, it must be observed to lay about two-thirds of it over the two large parts, and only one-third over the other, otherwise the pressure will not be equal. Iron rollers are sometimes made in three parts, as above, but being all in a line, and close together, they are apt to be choaked by gravel and small stones, which cannot happen in the construction here recommended. It is contended, that if such a roller were generally used upon roads, especially when newly made, it would save a great deal of expence in repairing them; for it cannot be expected that any new road will immediately bear wheel-carriages, or continue long in repair, when composed entirely of loose materials, without the smallest pains being taken to consolidate them together. Frequent and heavy rolling would therefore produce the most beneficial effects, and would tend very much to keep the road free from deep ruts and holes; besides, there is nothing could contribute more effectually to promote and preserve firmness and solidity, two qualities without which it is impossible any road can, with propriety, be called a good one, or have the necessary degree of solidity and firmness.

The advantages that would result from this mode of con-

ſtruction would be various: by being level on the ſurface, every part of it is equally commodious for carriages, conſequently it will all be equally travelled upon, and the deep ruts ſo frequent in other roads, will almoſt entirely be prevented.| It will therefore be much eaſier kept in repair, and, if properly managed at firſt, will be made at leſs expence than the common roads, eſpecially in a ſandy ſoil, or where ſand or gravel is eaſily procured. The draft will be much eaſier on ſuch a road. And one very important advantage is, by having an under-ſtratum through which the water can penetrate, and the cavities among the harder materials being filled with the ſame porous ſubſtance, no water can ever lodge on the ſurface, nor can it ever become ſo dirty as other roads are in wet weather; all the water that falls on the ſurface, unleſs perhaps in very heavy rains, being conducted away underneath and in every part. And it may be added, that from the ſmall drains on each ſide of the road, croſs-drains ſhould be carried through the fences, provided the level of the ground will admit of it, at the diſtance of every ten or fifteen yards. Theſe croſs-drains may be made of wood, with about an inch bore, or of ſtone, if preferred.

It would be of great advantage to this ſort of road, as well as to every other road where the ground is incloſed on each ſide, that the fences ſhould be ſunk towards the fields, and the water be conducted through to theſe ſunk fences, inſtead of the common method of leaving large open ditches and drains on each ſide of the road. It muſt alſo be particularly attended to, that on all ſloping roads on a declivity, where the water is apt in heavy rains to run upon the ſurface, or at the ſides, that it ought never to be allowed to run in the ſame direction more than ten or fifteen yards, but at that diſtance to be conducted away to a ſide into the main drains. It will then do little or no harm, as it can never increaſe beyond a very weak ſtream; but if it is allowed to run one hundred or two hundred yards, it will probably be increaſed to ſuch a ſize before it reaches the bottom, that it will waſh away a great deal of the materials, and may beſides very much injure the road or fences on each ſide of it, which would be highly diſadvantageous in many reſpects. Beſides, it is ſuggeſted, that a road formed on this plan need not be quite ſo wide as roads in general are made, for the whole ſurface of it will be in uſe from one ſide to the other, and therefore from twenty to twenty-four feet wide is quite ſufficient, unleſs near populous towns or extenſive works, where great numbers of carts or waggons are employed. And in the interior parts of the country, twenty feet in width will anſwer every purpoſe required. He has obſerved in ſeveral places, where the roads have not been above eighteen or twenty feet wide, and properly made from ſide to ſide, that they were in much better condition than the neighbouring roads, from thirty to forty or fifty feet wide. On theſe wide roads, formed in the uſual way, there is ſeldom more than eight or ten feet in the middle of them generally made uſe of; the remainder one on each ſide being occupied by heaps of ſtones, ſcrapings, and other rubbiſh, which, although they may partly be of uſe ſometimes in repairing the roads, ought on no pretence to be allowed at all times, or at any time, to lie there; ſuch rubbiſh being not only diſgraceful on the ſides of a public highway, but even dangerous, particularly in the dark, for either carriages or horſes; beſides having various other diſadvantages ariſing from the growth of weeds, and the diſſemination of their ſeeds.

But in reſpect to the moſt proper and beſt form of the roadway of narrow lanes, as thoſe leading from village to village, in recluſe ſituations; where bridle roads, or pack-ways, have been ſo far opened as to admit carriages; or though the whole width of the lane may not be more than eight or ten feet, it is remarked by the author of the treatiſe on "Landed Property," that on ſuch a narrow ſpace, a whole barrel, or convex road, cannot eaſily be kept up. If raiſed, it preſently wears into a middle track, and two wheel-ruts, with foul drains on either ſide of them; and becomes, in wet weather, a dirty trough, which is unfit for either carriages or horſes, and in which a foot paſſenger has not where to ſet his foot. But that provided ſuch a lane be thrown into a ſhelving form, reſembling half a barrelled or convex road, a greater width of travellable road for carriages and horſes will be obtained; ruts will not be ſo liable to be formed; the whole of the water of rains will be thrown on one ſide; while the other will afford a comfortable walking path at all ſeaſons. And this, it is added, is now no longer merely a probable, but a tried improvement. Lanes, ten, twelve, or more feet wide, have been ſtrikingly improved by it. And it is further ſuggeſted, that when water, in a wet ſeaſon, is apt to ooze out of the banks on the upper ſide of the lane, a narrow channel is to be cut, to prevent its overflowing the road: or, in forming the bed of the road, the inclination may in ſome caſes be reverſed; ſo as to throw the drain on that ſide of the lane from whence the ſpring water iſſues: thus the ſame drain will ſerve for the ſpring and the rain-waters. And it is added, in regard to this ſemi-convex form of road, that it is applicable, not only to narrow lanes, but to the ſides of hills; where the road, as it generally ought, is conducted ſidelong, not directly, up the ſlope. By this form of the road, the whole of the water which falls upon it will be got rid of, without inconveniency or expence. And the bed of the road, for this purpoſe, may be made narrower than for a full convex road; a circumſtance which, in ſome caſes, may become a ſaving of much expence. The upper ſide of a road in this form being nearly level, and firm to the foot of the ſteep, would be choſen by aſcending carriages; while the lower ſide would acquire a looſeneſs of ſurface, and be uſed by laden carriages going downward; and while a raiſed foot-path, on the lower margin, would be a ſecure guard, and a relief to the apprehenſions of timorous travellers.

But in relation to the width of public roads where a blank is given, it ſhould be regulated, Mr. Marſhall ſays, by their publicity, as it is compound folly to make a road wider than its uſe demands. He ſuppoſes that there are few roads, even near populous towns, that require a greater width than about thirty-three feet. But every public road, under common circumſtances, ſhould have a line which is travelable at any ſeaſon, and of ample width to permit two carriages to paſs each other with freedom and ſafety. This ample width let us ſet down as one ſtatute pole. In deep clayey diſtricts, where hard materials are difficult to be procured, a ſingle road, of half a pole in breadth, with dilations at proper diſtances, to let carriages paſs each other, may, in many recluſe ſituations, be adviſable. This regards the breadth of the winter road, for carriages and animals of burden. But that the width of a public *lane* requires a more enlarged view. On the plan offered, it is to contain, not only a wet-weather road, for carriages and horſes; but a ſummer road, and driftway; as well as a foot-path, which may be uſed in any ſeaſon. He obſerves, that in many parts of the greateſt public roads acroſs the kingdom, the lane is not more than twenty feet wide. But this being filled with hard materials, from hedge-bank to hedge-bank, carriages alone ſeldom find any inconveniency in theſe narrow parts. But where carriages, and large droves of cattle or ſheep meet in them, ſtoppages are unavoidable, and great inconvenience is of courſe ſuſtained.

And it is thought, that the width of the *driftway* ought, like that of the hard materials, to be guided by the publicity of the given road. In a great public road, it ſhould certainly be wide enough to let two carriages paſs each other, or one pole in width. But in one of leſs publicity, or where the exiſting lane will not admit of that width, a ſingle carriage path may ſuffice; as this being a continuance of the width of the hard road, no difficulty in paſſing can be experienced, it is ſuppoſed, from it.

But the width of the *foot-path* and the ditch may vary from half a pole to ten feet.

It is therefore concluded, that on theſe premiſes, the width of the lane of a great public road, near a populous trading place, ought to be fifty-nine feet and a half; and that of a common market-road, thirty-three feet. And theſe widths, without any previous intention, come out nearly the ſame as thoſe directed by act of parliament, for the lanes of turnpike roads and highways. A great error in the act, however, is, that the lanes of all turnpike roads, ſhall be ſixty feet wide: thus incurring a ſerious waſte of land; and creating great nuiſances; which green lanes ever are to the occupiers of adjoining lands. He from this ſuggeſts, that where exiſting lanes are wider than all the deſired conveniencies require, ſlips ſhould be ſold off their ſides, and be laid to cottages, or to the adjoining incloſures; having receſſes here and there, in which to lodge materials. It has long appeared to his mind an evident poſition, that every part of a public lane ſhould be uſed; and conſequently that no part of it ought to be a nurſery for weeds, or an unprofitable common paſture for ſtarving ſtock. Still he remarks, that a wide lane has its advantages; eſpecially in a low cloſe ſituation. It gives freer admiſſion to the ſun and air than a narrow lane, and the road dries more quickly. And further, that by permitting a more forcible current of wind, the pulverized materials, or dirt of the road is, in dry ſeaſons, carried off in the ſtate of duſt; leaving the uſeful materials undiſturbed. And it is highly proper to place the principal line of road in the midway of the lane, that it may be the moſt effectually expoſed to the agency of the ſun and wind.

Mr. Beatſon even ſuſpects, that, in the whole kingdom, thouſands of acres of fertile lands are loſt to the public, merely by making the roads ſo much wider than there is any neceſſity for. In the vicinity of large towns, they ſhould have an ample width, as 30 or 40 feet; or, in ſome caſes, conſiderably more, as near the metropolis. But the practice of making them 40 or 50 feet wide, as is ſometimes the caſe, through a thinly inhabited part of the country, or near the moſt pitiful villages, where even 20 feet would be ſufficient, is, he contends, a mere waſte of ground for no purpoſe, and occaſions a very great additional expence in making ſuch roads, which certainly might be avoided. Suppoſing the medium neceſſary width of road to be 7 yards, or 21 feet, and that the medium width now made is 11 yards, or 33 feet; this is, upon that ſuppoſition, 4 yards wider than is neceſſary; which, in every mile, is a loſs of 1 acre 1 rood and 2 perches: and ſuppoſing there are 5000 miles of ſuch roads in the whole kingdom, there is a loſs of more than 6300 acres, which, if eſtimated the ſame as the improved value of the waſte lands, at 27*s. per* acre, and at 30 years' purchaſe, would produce 255,150*l.*; a ſum which, if laid out in improving the roads, and making eaſy communications through different parts of the kingdom, would be of the greateſt public advantage. And it is evident, that where they have the width ſtated as neceſſary by the firſt of the above writers, the loſs ſuſtained in this way muſt be ſtill greatly more conſiderable.

Mr. Marſhall thinks, that in the operation of forming roads of the public kind, the firſt buſineſs of the road-ſurveyor is to examine the lane, or other ſcite of the intended road, in every part, to aſcertain whether offenſive waters lodge beneath it, and whether quickſands or land-ſprings break out in a wet ſeaſon, in which this examination is requiſite to be made. If defects of this kind be found, effectual ſubdrains are to be run up to them from the ditches or ſide-drains of the lane, or other ſcite. And that the next operation is to adjuſt the ſurface of the ſcite; to ſtrike off the protuberances, and fill up the hollow parts; and thus, in ordinary caſes, to mould it to the firſt proper form, or according to ſome of the other forms that have been mentioned; the foot-path and the higher ſide of the ſoft road being raiſed with the earth which is required to be taken off the bed of the hard road, whoſe baſe or foundation ought to be formed with peculiar care. Every part is required to be firm and ſound; dry earth or hard materials being rammed into every hollow and yielding part. It is ſuggeſted that the firſt form is adapted to firm binding materials; to ſuch as acquire, by wear, a repellent ſurface, and ſhoot off the waters that fall upon it; not to thoſe which are looſe and incoheſive, yielding to preſſure, abſorbing rain-waters, and conveying them down to the baſe or bed of the road. Theſe require a flat or a convex bed, free from obſtructions on either ſide, ſo that the abſorbed waters may effect their eſcape at the baſe. And that on this firm and level bed the largeſt of the hard materials are to be laid; next, thoſe which are more finely and evenly broken; and, laſtly, a covering of ſtill finer materials: to aſſiſt the roller in giving ſufficient firmneſs to the ſurface, and to render it immediately capable of being travelled upon.

But in regard to the proper materials for conſtructing roads with, Mr. Marſhall thinks that although every diſtrict may be ſaid to have its own material, and often without choice or alternative, yet there may be inſtances in which uſeful materials are overlooked or diſregarded. And that in ſome parts, particularly in Lancaſhire, large paving ſtones are in common uſe; ſome of the more public roads being rough pavements, reſembling the ſtreets of ill-paved towns. But that in the northern, and ſome of the midland provinces, broken quarry ſtones are the ordinary road material; and that, taking the kingdom at large, they are the moſt common material. But in the ſouthern and weſtern counties, flints and other hard field ſtones, gathered off ley grounds, are in common uſe; and in the neighbourhood of the metropolis, and in other parts of the kingdom, ſharp flinty gravel is a favourite and valuable material. In many parts of England, ſmooth, water-worn, pebbly gravel, collected on the ſea-beach, and in river beds, is uſed; and if the pebbles are of a hard texture, and be properly broken, to make them bind, or unite firmly together, a good road may be made of this material. In ſome caſes, ſand and ſilt, or fine ſea-ſand, have been employed with ſucceſs.

It is likewiſe added, that the artificial materials of roads, which he has met with, in quantity, are the droſs and cinders of iron and copper works; and burnt clay, (burnt as bricks in heaps,) which in a clayey diſtrict, deſtitute of other materials, and where fuel is cheap, may be found a valuable ſubſtance for the purpoſe. It is ſuggeſted by Mr. Beatſon, that in a ſandy ſoil the roads may be made on the new conſtruction, he has already recommended, with the greateſt eaſe. In ſuch a ſoil, there will be nothing more to do than to level the ſurface properly, fill up all the hollow parts, roll it well with the long wooden roller, and lay on the materials intended to finiſh it with, in the manner di-

rected, and then roll it with the heavy roller, as has been advifed above.

But in cafes where the foil confifts entirely of a deep loofe fand, the beft and eafieft way to make a lafting road is, to form it to the width intended for the hard materials, and then to let a channel be dug at leaft 18 inches in depth, and about the fame width: let thefe be again filled, and firmly built up with ftrong turf or clay, or any other folid fubftance that will prevent the materials to be laid on the road from fpreading to either fide; openings being left at every 10 or 15 yards, to let the water that falls on the middle part of the road more eafily through. Where the form of the ground requires making up, a little wall of the fame nature, inftead of digging a channel, may be built on each fide, nearly as high as the furface of the road is intended to be. Thefe will prevent the hard materials laid on from fpreading, which is the principal caufe of roads made in fuch foils giving way in fo fhort a time; and thefe materials will not be fo liable to fink into the fand, if it is properly rolled before they are laid on, as well as at different periods after it is finifhed. And if there be a fence on each fide of the road, and materials can be fpared to cover it from fide to fide, there will be the lefs occafion for the little walls; as thefe are only intended to keep the hard materials within the bounds prefcribed, in cafe it is not judged proper to lay them the whole breadth of the road. Where, however, thofe walls are thought requifite, the fpaces, by being covered with a little gravel or freeftone-fand, will make very good foot-ways or horfe-roads; but in a road finifhed in this way, there will be no occafion for horfe-roads diftinct from the main road, as the whole, if kept in proper order, will, he fuppofes, be fufficiently fmooth and fafe for horfes, or even foot paffengers, to go upon at any time. In fpeaking of the making of roads through a clayey foil, it is remarked that thofe formed in fuch diftricts are in common the moft unpleafant of any, chiefly on account of proper precautions not being taken to prevent the water lodging on the furface; fometimes, perhaps, owing to a want of proper materials, fuch as ftones or gravel: but he has often feen the very worft of clay roads, even where no fuch excufe could be given. And that it feems hardly ever to have occurred to thofe who had the direction of fuch roads, that fand, properly applied, would in a great meafure remedy all the defects complained of; and there are few parts of a country where fand of fome fort, or free-ftone-rock, or fandy gravel, may not be obtained by fome means. In certain fituations it may, no doubt, be more expenfive and difficult to procure fuch materials than in others; but thefe are local advantages, which road-makers muft lay their account with. But the exceffive inconvenience of bad roads, the expence occafioned by the tear and wear of wheel-carriages and harnefs, the rifk of diflocating the limbs of horfes, together with many other difadvantages, ought to ftimulate all concerned to exert their utmoft endeavours to make roads good, and eafily paffable, be the difficulties what they may, that ftand in the way of them.

It is hinted, that in fuch places as where no hard materials can be got, if the road were formed nearly in the fame manner as that firft noticed, the evils complained of might probably foon be remedied. The clay fhould be excavated, fo as to form a ridge in the bottom of the excavation. There fhould be fmall openings or drains at every 10 or 15 yards, or at every hollow place, to conduct away the moifture into the main drains. If this excavation is then filled with fand, or any other porous matter eafieft to be got, and finifhed as formerly directed, there is no doubt but the road would foon become as good as could be wifhed for. Something fimilar to this he has known put in practice by a very ingenious gentleman in Chefhire, on whofe eftate, being a ftrong clay foil, the roads were fo exceffively bad as hardly to be paffable. He dug away the furface of the road to the depth of 12 or 14 inches, and having the command of plenty of fand, he filled up the excavation therewith, and covered the whole with gravel; by which means he has now made, fo far as completed in this manner, as pleafant a road as one could wifh to travel on. He is not certain if he left the bottom of the excavation with a ridge in the middle, as here directed; but he is clear this would be an advantage, as well as the outlets at certain diftances, to let away the water.

And in conftructing roads through boggy or moraffy foils, it is advifed, after proper fteps have been taken, to drain off as much of the water as poffible, by deep ditches or drains withinfide the fences, if inclofed, or intended to be inclofed, on each fide. Thefe drains fhould be caft at leaft a twelvemonth before any thing elfe is done towards making the road; for if the place is very boggy, it will be found to fubfide confiderably after the water is drained away; and fome parts will fubfide more than others, in proportion to the depth of the moffy foil, and to the quantity of water lodged there. Thofe parts will, therefore, be the better feen the fecond feafon than the firft. All hollows or irregularities fhould then be filled up and levelled, either by taking from the heights and filling up the hollows, or by fome other proper materials neareft at hand. In either cafe, the furface fods fhould, with a pufh-plough or paring fpade, be carefully pared off the heights to be lowered, and alfo off the hollows to be filled up. Thefe fods fhould be laid afide, till thofe places are brought to their proper level, and fhould then be laid on again. This will make the whole furface of an uniform toughnefs, which would not be the cafe where the fods are not laid on in this way. After this has been done, the breadth of the intended part for receiving the hard materials fhould be marked off; then let that part be covered with fand, or fuch porous fubftance, as before recommended, to the thicknefs of at leaft 10 or 12 inches. Then roll this, and finifh it as already directed; and there is no doubt but a road made in this manner may be as good through a mofs as in any other fituation. This he fpeaks of from experience, having feen the moft pleafant roads made in this manner, through moffes formerly thought impaffable. When the mofs is too foft to admit horfes upon it, the fandy ftratum may be rolled by men, the weight of the roller being regulated by the ftone box, according to their ftrength. Sometimes the rolling is altogether omitted; but it is much better to roll, when practicable. It is added, that there are other methods of making roads through moffes; as by laying a foundation of broom, furze, or heath, and then the hard materials above them. But fand is greatly preferable, where it can eafily be got, and when the track of the road is properly drained, as it always ought to be, before any thing is laid upon it with a view of making a road. Thefe principles and directions are, it is faid, equally applicable on all other forts of foil, with trifling variations, according to the peculiar circumftances of the cafes.

And it is fuppofed, that in the above cafes the roads were formed where the fcite or track was nearly level from one fide to the other; but there are other fituations, fuch as when cut or formed on the fides of hills, where fome other precautions become neceffary to be attended to. In thefe cafes it is obferved, that in making them it frequently happens that the excavation affords a fufficient quantity of materials for the purpofe; and the part cut out

of the solid very rarely requires any covering laid upon it. This, however, depends on the nature of the soil. If the whole breadth of the road is formed from the solid, and that is sufficiently hard, no extraneous materials will be necessary; but if the soil is a compound of clay, or of a soft nature, the above rules and regulations must be had recourse to. And that where the parts are made up from the excavation, they ought to be formed considerably higher at first than the other parts, as they will naturally subside for some time afterwards, and the hard materials should not be laid on till they have sufficient time for that purpose, which may be greatly expedited by rolling; and it should be observed, that it is much better to be obliged to lower those parts to their proper level before the materials are laid on, than to be under the necessity of making up any of them at the time. And further, that where the hill is of a considerable height above the road, a good deal of water will sometimes come down. In this case it is in general better to intercept that water at some little distance from the side of the road, than to allow it to run down the face of the bank. If allowed to run down this face, it will very soon moulder it away, especially in frosty weather, and will always choak up any drain that may be made, whether covered or open; for if covered, the earth that moulders down will in a short time become so close, that water will not get through it to the drain before it runs off upon the road; and if open, it would be extremely difficult and troublesome to keep it clear. In this case, by intercepting it about four or six feet from the brink, and conducting it away to the most convenient outlet, it would be much easier to keep the road dry. If the face of the bank be irregular, the water may still be conducted away, by making the drain recede from the brink at such places, and keeping the course always at a proper level, or it might, he supposes, be let off at every hollow place by small recesses faced up with stone, or by wooden spouts sunk upright in the bank at every such hollow; to conduct the water from the upper drain to a cross covered drain below the road, by which it may be carried away at the lower side, without any injury being done to the road. And it is advised, that in the forming and making of these, as well as all other roads, the preventing of any water running on them, except what falls from the clouds, should carefully be attended to. Where this cannot easily be done, and where it is necessary to allow a stream to run along the side of a road, the drains or ditches which, as before observed, should be withinside the fences, should be made of a proper size accordingly, as the small drains filled with sand or gravel, as already recommended, are only meant for such roads as can have no extra water coming upon them in this way.

But in respect to *private* roads, the nature and manner of laying them out has been already noticed. And in respect to the method of forming them, Mr. Marshall says, it is the same where strong cohesive binding materials are made use of, whether in a lane, or across open ground. The mode he advises is to form a receptacle for such hard materials, twelve or more inches deep; either by digging to this depth beneath the natural surface, and carrying off the excavated soil; or to half the depth, disposing of the soil raised in the operation on each side of the receptacle; so as to elevate the general surface of the road above that of the adjacent ground. And in this receptacle deposit the materials; leaving the surface either in a convex or a semi-convex form, as the turn of the surface of the ground to be travelled over may direct: the margin or margins of the road, at which the rain-water is to be collected, being left a few inches beneath the adjoining sward. But that in forming roads of every description with sand, loose gravel, or other incohesive absorbent materials, which imbibe the rain-waters that fall on them, a receptacle of that kind is altogether improper. Such materials ought to be laid on a level or an elevated surface; and a shallow drain to be open on either side, for the absorbent waters to filter into; thus preventing a surcharge, and freeing the surface entirely from collected moisture, which would be highly injurious to it. And it is here added, that the surface of a road which is formed of well-broken stones, binding gravel, or other firmly cohesive materials, and which is much used, presently becomes repellent of the water which falls upon it; no matter as to the basis on which they are deposited; provided it is found and firm enough to support them. And that where the situation is low and the land of a moist retentive nature, a deep drain on one or on each side may be proper to give due firmness and stability to the base. Such drain, however, is not to be sunk close along the margin of the hard materials, to deter horsemen and carriage-drivers from coming near it, but a few feet distant from it; so that every inch of the hard road may be used with equal pleasure and safety, and a commodious driving and walking path be formed between the road and the drain; proper channels being cut across it, in order that it may be kept properly dry. And further that in a dry situation, as across a gravelly or stony height, little more is frequently required than to remove the surface mould, and lay bare the rock or the bed of gravel beneath it; and then to give the indurate base a round or a shelving form, as the lying of the ground may require. In this way a travellable road may be made, and kept up at one-tenth of the expence incurred by the ordinary practice in this case; which is to gather up the surface soil into a ridge, and on this soft spongy bed to lay coat after coat of some hard materials, fetched perhaps from a distance! at much expence for the purpose.

But in addition to the above sorts of roads there are still others, which require some art to form and keep them up in particular situations; these have the denomination of carriage and horse-tracks, and are described under these different heads.

Methods of Repairing Roads.—It is noticed by the author of the "Landed Property of England," that this is a business that incurs a heavy expence on landed property, and of course requires the peculiar attention of the proprietors and managers of land. And in the paper mentioned above it is observed, that where the funds of the parish will admit, which would generally be a saving, that proper persons should be appointed in them, or have the charge of a certain extent of road to see where any part is giving way or getting out of order, and to direct their immediate repairs. Also to take care that no water stands in the hollows or ruts upon them. And, that the summer season is the best not only for making, but for repairing roads, nor ought they on any account to be touched in winter, unless to give a temporary aid to some sudden breach that is perhaps almost impassable, or to let off any standing water. Yet nothing is more common than to see a number of labourers employed on the highways in winter, when the days are short, and but a few hours labour can be obtained of them. Indeed so little attention is there often paid to repairing the highways, that sometimes old infirm people are employed for the purpose, as if repairing roads were a sort of trifling bye job, merely for the employment of paupers, or lame, miserable objects, who can get no other means of subsistence. And Mr.

Marſhall thinks, that in this ſort of work, the beſt ſervice of the ſurveyor is to keep their ſurfaces ſmooth and even; ſo that rain-water may find a free and ready paſſage to its proper drain. Ruts and hollow parts are to be filled up level, or even with the general ſurface, as often as they are formed, and perfectly free from water. This attention is more eſpecially requiſite to a new made road, whoſe bed and foundation are not yet fully confirmed. But in every caſe, and at all times, a ſolicitous regard is due to this moſt important, yet moſt neglected part of road ſurveying. Much expence of materials and labour may thereby be ſaved, and the great end of road-making be fully obtained: namely, that of rendering the road in all ſeaſons eaſy, ſafe, and pleaſant to the traveller, as well as eaſy in the conveyance of all ſorts of articles. Beſides, he conceives, that in this operation, as well as that of making new roads, very much depends on breaking the materials *evenly*. For, by doing this, the wear of the road becomes regular. Where the heads of large ſtones riſe above the general ſurface, they become obſtacles to carriages, and ſtumbling blocks to horſes; beſide their tending, by the jolting motion which they give to carriages, to indent the ſurface on either ſide of them, and thus to increaſe the roughneſs, and haſten the decay of the road. It is added, that by the law of gravitation and the action of wheel-carriages, a pit or hollow place in the ſurface of a road is made deeper every time the wheel of a carriage paſſes through it. The periphery of the wheel acts as a chiſſel, and in falling into the hollow receives an impetus or acquired force in addition to the actual weight it is loaded with; and, in addition to this, an undue proportion of the general load is, by placing it out of its upright poſture, taken from the upper and thrown upon the lower wheel. Likewiſe hard protuberances, beſide being dangerous or diſagreeable to travellers, whether on horſeback or in carriages, are injurious to a road, as being the cauſes of pits and hollow places in its ſurface. Every hard protuberance, as the point of a ſtone ſtanding above the general ſurface of the road, or a large ſtone lying looſe upon it, is productive of four impreſſions: namely, two, by throwing additional weight upon the oppoſite wheels (going both ways), and two more by the impetus or acquired force of the wheels (paſſing both ways) in falling on the ſurface of the road. He therefore conſiders it to be the firſt duty of the ſurveyor, not only to fill up the ruts and hollows, from time to time, but to pick out or to cruſh with a heavy hammer the ſtones, whoſe tops riſe above the general ſurface; as well as to gather off thoſe which lie looſe upon the road; the latter being an operation that is readily performed, yet frequently neglected, and in ſome places to a ſhameful degree, eſpecially in the northern parts of the iſland.

And in reſpect to the ſizes moſt proper for road-ſtones it requires much latitude. Not only the intended uſe of the road, but the nature of the material is to be conſidered. A road for broad-wheeled carriages of burden, only, may be made of larger ſtones than one for narrow wheels. And hard ſtones require to be broken ſmaller than thoſe which more readily wear down, and form a travellable ſurface. For when once the ſurface of the materials becomes united and cemented together, and its rock-like texture eſtabliſhed, the ſtones that are cruſhed, and the ſmaller fragments which are ſplintered on, in wear, ſerve, he ſuppoſes, to incruſt and bind together the ſtratum of ſtones which lie next, in ſucceſſion, beneath: eſpecially if proper attention be paid to the irregularities of wear, and to bring back the ſurface, wherever it is requiſite, to its original evenneſs of convexity where that form is adopted:—ſo that it may, in every part, act as an arch, and may be able to reſiſt, with the greateſt firmneſs, the weight with which it may be impreſſed. It is, however, to be obſerved, that, in forming and repairing roads with ſtones of ſize, a conſiderable mar of the expence ariſes from the labour of reducing the materials; and, in conſequence, the ſmaller they are broken the greater becomes the expence. This, on ordinary occaſions, is a ſerious conſideration. Hence, in conſtructing and repairing common roads, it is adviſable, inſtead of reducing the ſurface ſtones to ſmall fragments with the hammer at a great coſt, to cover them with materials that are already reduced; as the rubbiſh of ſtone quarries, ſoft ſtones, or gravel, or the ſcrapings of the road to be repaired. Such cementing materials being waſhed and worked down by rains, and the action of carriages, and the feet of travelling animals, among the ſurface ſtones, aſſiſt much in binding and fixing them in a firm cruſt; and in making the road immediately paſſable by horſes and light carriages; moſt particularly if the whole be compreſſed, and united together with a heavy roller (ſuitable to the purpoſe), repeatedly paſſed over the ſurface of it. And another good method of ſaving expence in this way, where materials are readily procured, is that of placing the coarſe unbroken ſtones or other hard materials in the bottom part or bed of the road, covering them over with gravel, or other ſorts of materials that are of a ſmall kind. However, where the hard materials are broken down ſmall and evenly the roads are found to wear the beſt.

The proper materials for repairing roads are in a great meaſure the ſame as thoſe which are uſed for the making of them in the firſt inſtance. The writer of the Agricultural Report of Middleſex thinks the rounded ſtony materials of the nature of flint, found in gravel pits and river bottoms, are in every reſpect more fit for roads than any other flinty matters. The materials for the ſupport of great public roads ſhould, it is ſuppoſed, be ſelected from among ſuch ſtony ſubſtances as are tough as well as hard; for this purpoſe, hornblende is believed to be particularly ſuitable, to which may be added whinſtone, baſalts, iron-ore, and all ſuch ſtones as contain iron, as well as the flag, or the refuſe of furnaces. The comparative weight which ſtones of ſimilar ſize and figure can ſupport without being broken, it is imagined, the criterion by which to try them for this uſe.

Mr. Beatſon thinks, that if the above directions were ſtrictly attended to, and every appearance of a breach or defect in a road at repaired, the ſame materials, when diſplaced, would very often, if properly relaid, and fit for the purpoſe, repair the part beginning to fail; whereas, if neglected for ſome time, and allowed to get much out of repair, it will probably require a conſiderable additional quantity of materials, and thereby occaſion a great deal of expence that might have been ſaved. He alſo ſuggeſts, that during the time of hard froſt, it may be very proper to drive materials, and lay them down for the purpoſe of being at hand to repair the roads when the ſeaſon permits, but ſuch a time is the moſt improper of any for applying thoſe materials. And that in laying them down it is a very general practice to place them in ſmall heaps along the ſides of the road, and even encroaching ſometimes very much upon the ſpace allotted for travelling on. This ought on no account to be allowed (unleſs thoſe materials are to be immediately uſed), for reaſons ſo obvious, it is unneceſſary to mention them. It would be much better to have receſſes at certain convenient places, for the purpoſe of laying the materials in till wanted; by which means the inconveniencies attending the common way would be totally

avoided, and travellers might then, without interruption, uſe any part of the road they found beſt; and beſides, there would then be leſs occaſion for making the roads ſo wide as they are generally made, which would undoubtedly ſave a great deal of money in keeping them in repair, or proper condition.

It is ſtated, that rolling of roads with a heavy roller, as directed above, would be a very beneficial practice in keeping them in good repair, eſpecially if the hard materials, that are worked out of place by the wheels of carriages, are raked in again previous to the roller paſſing over them. This would be an eaſy and expeditious operation, and if taken in proper time, would, in many caſes, be all that is neceſſary to put the road in repair. It is, however, an implement that is very ſeldom made uſe of for this purpoſe by the overlookers of roads.

And the uſe of machinery has probably been hitherto too little attended to in the execution of this ſort of work; but from the increaſing price of hand-labour, it certainly at preſent demands the ſerious notice of the managers of this ſort of buſineſs. For dragging over roads, when much out of repair, in order to replace the ſtones or gravel diſturbed by wheel-carriages, a ſort of harrow has been invented by Mr. Harriott of Great Stanbridge, in Eſſex, for which he received a premium from the Society for the Encouragement of Arts, &c. and of which he gives the following account. "Being appointed ſurveyor of the roads at Michaelmas, 1786, and finding them very bad, I provided a ſufficient quantity of ſtones and gravel againſt the next ſummer, to cover the roads pretty thick; but when ſo done, I found the heavy loads of chalk, gravel, and corn, ſoon turned the ſtones out, and made almoſt as deep a rut or rake as ever. Stubbing the quarters in I found an endleſs job, as well as a great expence; I, therefore, contrived the road-harrow, and by the help of which I have, during the laſt ſummer, at a very trifling expence to the pariſh (after the ruts were again filled up with ſtones), kept the roads in extraordinary good condition. A man, a boy, and two horſes will do three miles in length in one day, completely harrowing down the quarters, and drawing the ſtones together, which, by means of the mould-boards, are dropped into the ruts, far better than a man can ſtub them in. Now, if a man was employed to ſtub, he could not do it for leſs than a penny *per* rod, of ſixteen feet and a half, (the moſt common is three halfpence, or two-pence *per* rod, if they ſtub the outſide as well as the inſide quarter,) which would amount to one pound ſix ſhillings and eight-pence for one mile in length, conſequently to four pounds for three miles, which the road-harrow will do in one day; and for which I charge the pariſh for man, boy, and horſes, only eight ſhillings." And it is further ſtated by him, that it does the work better, as well as cheaper; that ſeveral other pariſhes are uſing them, and he thinks the uſe of them will ſoon become general, eſpecially where roads are mended with gravel. The head of the harrow is three feet long, from outſide to outſide of the bars. The bars four inches ſquare, and the length of them five feet. The mould-boards extend eleven inches farther, which is neceſſary to draw the ſtones (which the teeth of the harrow work up to the top) nearer the middle of the road. The mould-boards are four feet two inches long, ten inches deep, and two inches thick; they are ſhod with a bar of iron, and lined about ſix inches high with an iron plate. The teeth (which ſhould be ſteeled at the points) are one foot in length, from the under ſide of the bars to their points; they are one inch and a quarter ſquare, and are fixed with ſtrong nuts and ſcrews, with collars both on the under and upper ſide of the bars. The bars are made to go lengthwiſe inſtead of acroſs, to prevent them from ſplitting. The harrow is drawn by two horſes abreaſt, a boy leads the outſide horſe on the outer quarter, the other horſe goes on the horſe-path, the man ſteadying the harrow by the handles. Of courſe they take one inſide, and one outſide quarter as they go, and the other two quarters as they come back. And as this harrow is certified, by ſeveral people in the pariſh where it is uſed, to do more work with one man, a boy, and two horſes, in one day, and in a much better manner than could be effected by twenty men in the ſame time in the uſual way, it muſt certainly produce a prodigious ſaving both of time and money, and having been found to anſwer the purpoſe ſo extremely well, renders it worthy of attention by thoſe engaged in this kind of work.

Mr. Beatſon ſuggeſts, that after the uſe of this harrow, the heavy roller, noticed already, would have a very good effect, or there might be a roller of a lighter conſtruction faſtened behind the harrow, to roll at the ſame time; although the heavy roller would certainly make the beſt work. And likewiſe that other implements, nearly on the ſame principle, have been conſtructed, particularly one of which he was ſhewn a model by a gentleman near Cheſter. Its ſhape is in form of an iſoſceles triangle, which is laid upon the road, and drawn by ſhafts at the baſe. The two ſides, by meeting in an angle oppoſite the baſe, are ſuppoſed to draw the looſe materials towards the middle of the road. It has two ſmall wheels near the baſe or front, and one at the angle in the rear, with different contrivances for fixing the whole frame higher or lower as required.

It is alſo ſuggeſted that a machine for the more eaſily breaking ſtones to repair roads in the common way would be of very great uſe, as at preſent this is a tedious and laborious taſk. Under the article Machine, a very ingenious contrivance for removing the mud and dirt from roads has been deſcribed. But, although ſeveral contrivances have at different times been propoſed for facilitating the repair of roads, and leſſening the expence, yet that expence, Mr. Beatſon ſays, is no doubt very great, eſpecially in thoſe places where many heavy-loaded carriage tinually paſſing. The ruts made by the wheels ſoon become ſo deep, and the materials of the road are thereby ſo much torn up, that it is almoſt an impoſſibility, however hard the materials, to keep the road for any conſiderable time in proper condition, or ſtate of repair. It is, therefore, ſuggeſted, that theſe effects ſhould be attempted to be remedied by ſome means or other, as by a ſort of roller ſo fixed as to prevent the wheels from ſinking ſo as to form ruts.

It is evident that the principles and directions which have been given apply equally to private or parochial roads, which in general are in a worſe condition, from their being commonly worſe managed. The cauſes of their being in bad condition ſhould be attended to and removed, as much as poſſible, in the manner already ſuggeſted, as it is evident that they muſt have a great effect in promoting improvements in agriculture, by leſſening the expence of labour, and facilitating the means of conveyance of different articles. The effects of ſome ſorts of wheels have been more deſtructive to roads than others, and of courſe acts of parliament have been formed with the view of affording proper regulations in this reſpect. See Wheel and Waggon.

In ſpeaking of the draft from friction on the roads, Mr. Middleton, after conſidering what happens on thoſe made with gravel, and on iron railways, concludes, that, on gravelled roads, friction is not more than one-fifth part of the entire draft; the other four-fifths being occaſioned by

the obstacles of dust, sludge, loose sand and gravel. Hence it follows, he thinks, that by removing these obstructing causes, and keeping the roads constantly clean and hard, the draft would be so much lessened, as to render the present number of labouring horses unnecessary. It is suggested, that many of these inconveniencies may be got rid of; and the roads be in the way of getting more dry, clean, and hard, by removing the offending matter while in the state of dust, when it occupies the least possible space, and is in the most favourable condition for being taken away. A small portion of dust, it is said, when drenched with rain, becomes a large quantity of sludge, in which state it requires much labour to clear it away; on which account it is very advantageous to get quit of it before rain falls. This is, it is supposed, best effected by means of bush-harrows wrought every windy day. But some might be taken away after being scraped together by suitable machinery for the purpose.

It is intimated, that the time seems to be approaching, when iron must be made to contribute largely towards the public roads. It is thought that iron rails, or bars, may be laid along the present turnpike roads, in such a manner as to afford the most convenient track for all heavily laden carriages; and that this may be done without any material inconvenience to those of lighter weight and swifter speed. The great original expence of making such roads will, it is supposed, be sufficiently counterbalanced by their much longer duration, and the trouble fully compensated by the superior pleasure of travelling over them.

On the whole, it is supposed, that the keeping of roads in the most perfect repair is an object of high importance; for that until canals, or inland navigation, became general, the supply of the markets, and the price of every article, will be in proportion to the state of the roads over which they have to pass in their way to towns. Bad roads, it is said, require a greater number of horses to draw any given weight along them, than would be necessary for the conveyance of the same weight over good ones; which extra draft must be paid for by increasing the price of the article to the consumer. The same number of horses which, along *bad roads*, could only bring a scanty supply of the produce of the country from a small distance, can, on *good roads*, convey a more abundant supply, and from greater distances: which is calculated to lower the price of the necessaries of life in the metropolis and other large towns, rather than *advance* them in the distant counties, and have a happy tendency towards *equalizing* the prices between the towns and the country.

And the author of the paper already noticed, thinks it a matter of great consequence to have proper regard to the nature of the fences on the sides of roads, as on these the goodness of them, and the expence of upholding them, very much depend. Where the form of the ground and situation will admit of it, the sunk fence from the road, that is, with the deepest part towards the field, is by far the best. A fence of this sort, in the form of a ditch or drain, may be made of any depth without the least danger or inconvenience, which is not the case when open to the road; and the deeper it is made, the better effect it will have in keeping dry the foundation of the road, if properly constructed; nor will the road require to be so wide as usual, at the same time there will be fully more room to travel on; for if the fences are of this kind, the whole width of the road may with safety be occupied, but when open to the road a considerable space is lost, by the fear or danger of approaching too near them. And the fences on the sides may either be of stone, sod, or a hedge or paling; but ought not to be more than eighteen inches, or two feet above the level of the road (except a paling), and the top of them, if broad enough, may, in some places, be made to serve as a foot-path. Nevertheless, the fence towards the field may be six feet in height, or as high as the purpose of it requires. The road will thus receive the whole benefit of the sun, which is very essential towards keeping it dry, as well as the depth of the drains or ditches withinside the field, to which there must be proper openings at certain distances, as before recommended; and in winter, after heavy falls of snow, there will be little chance of a road fenced in this manner ever being blocked up, for it will be observed, when a storm of snow is attended with a high wind, that the drifted snow lodges chiefly about the fences, or where it meets with an obstacle to occasion an *eddy*; for where high fences are on the sides of roads, they are almost to a certainty in such cases blocked up, to the great inconvenience of the whole neighbouring country or district in which it happens. The planting of trees on the sides of roads should always be avoided as much as possible; but where rows of them are to be put in, it should never be done at less than ten or twelve feet distance from the fences, and not less than forty or fifty feet from each other, being constantly so situated as not to produce much shade on the road in the middle of the day.

Road, in *Ornamental Gardening*, that sort of carriage-way which is peculiar to residences of the country kind. They are of many different sorts, according to the nature, circumstances, and situations of the different places. But when properly laid out and formed, they have mostly one of the effects of building, at least, in a partial manner, which is that of giving force and spirit to scenes of verdure and cultivation. They should be laid out according to the nature of the situations; their directions and widths being provided by their conveniences, propriety, and utility. The methods of making and repairing of them are much the same as those employed for other kinds of roads; but in the finishing, their surfaces should be laid over with a finer and better coloured material of the gravel or some other sort, and they should be kept more perfectly rolled down and level; as the colours of such surface materials and the margins of such roads are principally what concerns picturesque effect, or that which is to be produced by them. In situations where the scene is avowedly of the artificial kind, the margins of them, according to the author of the work on "Country Residences," should be parallel to each other, and correctly defined; as in that part of an approach-road, which comes within the parapet or fence which incloses the mansion, or in those roads which are within the bounds of the other more adorned parts of the ground. But in situations where the roads are not in these scenes, but are either in picturesque or natural pleasure-grounds, pasture-fields, parks, forests, dingles, or other similar places, the edges should be irregular, and more or less rough or smooth, blending or ragged, as is seen to take place in roads or tracks through similar scenery in wild nature. The excellent effects and superior advantages which result from the adoption of these principles in the formation and construction of roads of this nature, may often, it is said, be seen in those parts of much frequented approach-roads of residences, which are not thought proper or necessary to be subjected to the operation of the paring-iron, and the formal trimming of the gardener. And indeed, that one of the most striking deformities in picturesque scenery, is that of the formal, stiff, and harsh edges of made roads, as they highly disgust the spectator, and prevent the true effect which should be produced.

All roads of this sort should, therefore, be laid out, and

formed in such a manner as to harmonise as perfectly as possible with the nature, circumstances, situations, and scenery of the particular places in which they are to be had recourse to. See WALK.

ROAD, *Approach*, that variety of this sort of road which is peculiar to residences, mansions, or houses of the country kind, and which leads or conducts to their principal or other entrances. In their manner of being laid out, they should in their directions neither be too affectedly graceful, have too much waving in their appearance, be too much beset and intercepted with trees; or be too vulgarly formed in the rectilineal and direct manner, or be too abrupt in their nature. There is a certain kind of dignity, propriety, and fitness requisite in them, which is not easily described, but which, in given situations and circumstances, readily presents itself to the mind of the designer; and in consequence of the whole of the operations, both of conceiving and designing them, being so simple, they are, for the most part, marked out upon the ground with great facility,—easily improved upon, and, in their execution, the work is merely that of road-making.

The accompanying circumstances which appertain to roads of this nature have been already pointed out in speaking of them in general, and they ought to be well attended to, as much of their beauty and effect arise from them.

The only proper approach-roads to castles, Mr. Loudon says, have been supposed those of the avenue kind, but that there seems no reason in nature for such a rule; and the arguments drawn from antiquity are wholly insufficient to justify their constant introduction in such cases. However, wherever they exist with good effect, they should, it is said, be carefully preserved; and even, in some situations, avenue roads to mansions, straight private roads through monotonous cultivated countries, or public roads passing along eminencies, may be created and formed with great advantage and effect, as is the case in many places. Roads of this kind should always be so contrived as to afford the best effect, and to produce the greatest harmony, which the places are capable of admitting.

ROAD, *Drive*, another description of road belongingto residences of the rural sort, which is chiefly designed to shew and display the beauties of the places, or of the surrounding country, or of both at the same time. They are principally had recourse to in residences of the more extensive and elegant kind, being mostly contrived without any great difficulty. The main circumstance to be attended to in this business, is that of only shewing one sort of rural character at one time, but to display the whole, in succession, as much as possible. They are commonly formed, as to the road part, without much labour or trouble, being often simply made by levelling, and the materials upon the spot; they may, however, be constructed in the same manner as the other roads in such situations.

The leading, or striking characters of the spot, are here to be particularly regarded.

ROAD-*Gage*, a contrivance for the purpose of breaking road stones, or other hard materials, by. A ring, or an oval, of iron, of the proper size for the intended use, with a short handle fixed to it, will answer this intention very well. These gages are of great use in breaking stones by the load, or in other ways, before they are laid upon roads; and should always be known to the workmen previous to their undertaking the business. See ROAD *Stones*.

ROAD-*Harrow*, an implement of the harrow kind, contrived for the purpose of forcing in the sides of the ruts. One represented in the Essex Agricultural Survey levels the ruts and combs very expeditiously. It was invented by Mr. Patteson, and costs 5*l*. See ROADS.

ROAD-*Horse*, such a one as is employed in the teams on the road, and which in general performs the most laborious work. Under this description comes the greater part of all the horses in constant use, as it includes carriage horses of every kind, roadsters, and hacks. Road-horses of every denomination are, from their constant hard work, entitled to a proportionable degree of care and attention with the best horses in the kingdom; and should undergo the useful part of stable management, that so much contributes to the preservation of health in horses of a superior description. Those which have incessant labour, or which travel post, must be supplied with at least from one to two pecks of corn a day. Large and strong carriage horses, in perpetual work, require considerably more, or they will become apt to lose flesh by frequent perspiration. These rules, however, offer only a kind of general standard.

ROAD-*Materials*, all such substances as are employed, or made use of, in the making and repairing of roads; as those of stony matters of different kinds and qualities, various sorts of gravel, sand, and a variety of other articles. They should, in every case, be reduced as much as possible to the same sizes, as the regular wear of roads depends very much upon it. See ROAD.

ROAD-*Pick*, an useful implement of this kind with three points. It has much resemblance to the common pick-axe, only differing from it in having the flat edge-like end of that tool occupied by three strong tines, about six inches in length, and standing about six inches in width from the outside to the outside of them. It thus forms a sort of small trident, which is borne on the shank of the implement, and stands about six or eight inches from the socket and handle.

It is a very convenient tool in striking off the protuberances, and filling in the ruts of hard roads; as well as to level and adjust the surface with, in forming and repairing stone roads. The single end is likewise capable of being employed for letting off water from shallow ruts, or hollow places, as well as for many other uses of the common pick. See PICK.

ROAD-*Plough*, an instrument of the plough kind, invented and made by the late Mr. Brand, an ingenious blacksmith, in the county of Essex, at Lawford, near Maningtree. It is formed all of iron, and represented in the Agricultural Survey of that district. Its length is that of a common plough, with two small wheels, one before and the other behind; and the coulter part is strongly secured.

ROAD-*Roller*, a heavy kind of iron roller, formed in three separate parts, used for rolling down the loose materials on roads. It is drawn by a horse or horses in shafts, somewhat as in the common roller. See ROADS.

ROAD *Scraping Machine*, a contrivance made for the purpose of cleansing roads from dirt, &c. These machines are constructed in several different ways, by different makers; but a very useful one may be seen under the head *Machine*; which see. See also ROAD.

ROAD-*Stones*, all kinds of stones, whether of the field, quarry, or other sorts, that are employed in the forming and mending of roads. For some uses of this nature, the stones should be considerably reduced, even in constructing or repairing ordinary roads. Mr. Marshall has suggested, that by dropping road-stones through circular gages of different sizes, it will be found that, for repairing small breaches, those which pass freely through a ring, 2½ inches in diameter, may be considered as of a middle size; and

that for new forming or fresh covering the surface of a road, none ought to exceed 4 inches; $3\frac{1}{2}$ inches being, for these purposes, the middle size: that 2 inches and 4 inches may, as a matter of general information, be set down as the extremities of size of road-stones of a middle quality, for the above purposes. See ROAD-*Gage*.

ROAD-*Surveyor*, a person who has the care and management of a road, whether in the making or repairing of it. All such persons as are employed in this way should be well acquainted with the nature of laying out, forming, and keeping them in order. Each of the different methods, which are in common practice, ought to be well understood, as well as those had recourse to in particular districts or places. And, besides, he should be well informed with regard to every thing of a local nature that has any relation to them, and be a man of exertion and ingenuity.

ROAD-*Team*, any sort of team that is employed on the road, whether in carts, waggons, or other kinds of carriages. All teams of this nature should in general be well kept. See TEAM.

ROAD-*Work*, all such kind of work as is done upon the road, either by the labour of men or animals. It is also sometimes applied to the business of making and repairing of roads.

ROAD, in *Navigation*, denotes a place of anchorage at some distance from shore, and sheltered from the winds, where vessels usually moor to wait for a wind or tide proper to carry them into harbour, or to set sail.

When the bottom is clear of rocks, and the hold firm, and the place well covered from the wind, the road is said to be good. An open road is one which has but little land on any side.

The roads within his majesty's dominions are free to all merchant vessels, either of his subjects or allies. Captains and masters of ships who are forced by storms, &c. to cut their cables, and leave their anchors in the roads, are obliged to fix up marks or buoys, on pain of forfeiture of their anchors, &c.

The masters of ships, coming to moor in a road, must cast anchor at such a distance as that the cables, &c. may not mix, on pain of answering the damages. When there are several vessels in the same road, the outermost to the seaward is obliged to keep a light in his lantern in the night-time, to apprise vessels coming in from sea. See PORT.

ROAD *Aqueduct*, is an arch under a canal, through which a road passes.

ROAD *Bridge*, a bridge over a canal for the use of a road, instead of private use. See OCCUPATION *Bridges*.

Roasting

ROASTING, in *Metallurgy* and *Chemical Manufacture*, is a procefs by which the volatile parts of metals and minerals are feparated by the application of heat. The minerals are generally mixed with the fuel, and fired in heaps expofed to the open air. When the volatile fubftance is driven off with difficulty, the reverberatory furnace is fometimes employed.

This procefs is frequently, though improperly, called *calcining*, fince the latter is confined to the oxydation of metals. In expelling the volatile parts from lime-ftone and gypfum, the procefs is termed *burning*, and in the latter fometimes *boiling*. The term roafting is principally confined to iron, and other ores abounding with fulphur and arfenic.

The iron ores of this country are roafted for the purpofe of expelling fulphur, water, and carbonic acid. The former would probably injure the quality of the iron in fmelting; the latter would contribute to an expenditure of the heat of the furnace. The procefs is conducted in the open air, by piling the iron-ftone and fmall coal in alternate ftrata, allowing the mafs to burn till the coal is confumed. The iron-ftone, by this means, becomes of a red colour, and lofes much of its weight. In fome iron-works the procefs is performed in kilns, fimilar to thofe employed for burning lime-ftone.

The ore from which zinc is obtained is generally blende, which is the fulphuret of that metal. It is expofed to the ftrong hea of a reverberatory furnace, by which the fulphur is expellec, and the metal oxydated.

When the metals or their oxyds are themfelves volatile, and are combined with fulphur, roafting is not practicable: recourfe muft then be had to fome other agent, which will combine with the fulphur, and feparate the metal itfelf. Such is the cafe with *cinnabar* and *arfenic*. See the refpective metals.

Rock-salt

ROCK-*Salt*, in *Mineralogy* and *Geology*, a natural ſalt, of the ſame kind as common table ſalt. This uſeful mineral forms large beds and maſſes in many parts of the world, and even compoſes entire mountains. It occurs in large columnar or in ſpheroidal concretions, and alſo cryſtallized in cubes. Rock-ſalt is ſubdivided by Werner into two kinds, foliated and fibrous. The more common colours of foliated rock-ſalt are, white, grey, reddiſh-brown, and red; but ſometimes it is violet, ſky-blue, and green, and is more or leſs tranſparent or pellucid: it breaks into cubical fragments, which have a vitreous luſtre: the ſtructure is indiſtinctly foliated. In fibrous rock-ſalt the fibres are generally ſmall and curved; in other reſpects it differs little from the former. The taſte of both is like that of common ſalt. The red varieties are coloured by earthy matter and oxyd of iron; the white and tranſparent are extremely pure, being compoſed almoſt entirely of muriatic acid and ſoda, or, according to Davy, of chlorine and ſodium. In the pureſt kind alſo, there is ſcarcely any trace of water of cryſtallization. According to Henry, pure tranſparent rock-ſalt, calcined for half an hour in a low red heat, equal to four or five degrees of Wedgewood's pyrometer, loſt abſolutely nothing of its weight. It is remarkable, alſo, that if free from any adventitious moiſture, it may be ſuddenly and ſtrongly heated with ſcarcely any of that ſound called decrepitation, which is produced by a ſimilar treatment of all the varieties of manufactured common ſalt. The ſpecific gravity of the pureſt ſpecimens of rock-ſalt is about 2.170, of the leſs pure about 2.130.

Rock-ſalt is widely diſtributed over the globe; it appears principally in the lower ſecondary ſtrata. It is moſt frequently accompanied with ſulphate of lime or gypſum, and by beds of clay impregnated with ſalt. Beſide the beds of rock-ſalt which are known, numerous brine-ſprings in various parts of the world atteſt the exiſtence of this mineral deep under the ſurface, as it is evident theſe ſprings percolate beds of ſalt, or ſtrata impregnated with it. Several brine-ſprings have recently been diſcovered in the deep coal-mines

of Northumberland and Durham. In the coal-mines near Afhby-de-la-Zouch, in Leicefterfhire, there are fprings of brine 245 yards below the furface; and though thefe fprings are in the centre of the ifland, they are 140 yards below the level of the fea. How much deeper their fource may be, has not been afcertained.

The moft obvious hypothefis refpecting the formation of rock-falt is, the one which fuppofes that it was depofited from the fea, or by the deficcation of falt lakes which formerly covered the prefent continents. Againft this it has been objected, that the compofition of rock-falt is much more pure than the contents of fea-water, which contains a quantity both of muriate and fulphate of magnefia, fulphate of foda, and of fulphate of lime. Rock-falt is alfo found at great heights above the prefent level of the fea. Thefe objections will, in a confiderable degree, be invalidated by the confideration that whatever impurities there may be in fea-water, if the procefs of evaporation go on very flowly the falt will be cryftallized nearly pure. Of this we have an inftance in the fpecies of falt made at Lymington, in Hampfhire, called *falt cat*, which is gradually formed in the courfe of ten or twelve days, by fpontaneous evaporation of the liquor which drains from the common falt. This falt is fo pure (though evaporated from the moft impure part, the mother water, or refidue of fea-water), that 1000 parts contain only 12 of foreign impurities, or little more than one *per cent.* Thus if the deficcation of lakes or bafins filled with falt water were very gradual, as it muft be, except in the vicinity of fubterranean fires, the muriate of foda or rock-falt would be cryftallized before the other falts, which being more deliquefcent might be feparated and wafhed away. In this manner the fulphate of lime or gypfum, which exifts in fea-water, and accompanies rock-falt, may alfo have been depofited, and being nearly infoluble would remain.

The occurrence of rock-falt deep under the earth, or high above the level of the fea, can fcarcely form an objection to its formation from fea-water; for it is admitted by all geologifts, and is proved by undoubted facts, that the ocean once covered our prefent continents. Now by whatever procefs the dry land was raifed above the fea, whether by the elevation of the former, or the depreffion of the beds of the latter, extenfive hollows and clofed vallies muft have formed lakes of falt water, from which the falt might be depofited by evaporation. Some of thefe vallies or hollows would occur in elevated fituations. With refpect to the beds of rock-falt placed under other ftrata, however difficult it may be to explain the formation of the fecondary ftrata, the exiftence of organic remains in them prove that each ftratum was once the uppermoft part of the globe, and the ftrata by which it is covered were depofited upon it in fucceffive and probably at diftant periods. Nor is the difficulty greater with refpect to the ftrata covering rock-falt, than the ftrata covering coal and beds of coal-fhale abounding in vegetable impreffions. No organic remains have indeed been difcovered in the ftrata over the rock-falt of Chefhire, but they are commonly met with at greater depths over the rock-falt beds in Poland, and in other parts of Europe. The occurrence of rock-falt at the fides or feet of extenfive mountainous chains, may perhaps illuftrate its formation, as it is probable thefe extenfive chains once formed the boundaries of inland feas or lakes, when the relative level of the ocean and our continents was very different from the prefent.

Rock-falt is not mined in any part of our ifland, except Chefhire, though it was bored through at Droitwich; and it exifts, in all probability, in many of the weftern counties through which the red fand-rock extends We have proofs of its exiftence from the brine-fprings at Droitwitch, in Worcefterfhire, at Lemington in Warwickfhire, and at Afhby Wolds, in Leicefterfhire; and alfo in the counties of Northumberland and Durham, on the eaftern fide of England. The fprings at Droitwitch furnifh a brine as ftrong as thofe of Chefhire. A defcription of the rock-falt of Chefhire being given as an article of rural economy, we fhall proceed to give a fhort account of the moft important repofitories of this ufeful mineral in other parts of the world.

Salt is very abundant in Africa; all the plains and fandy defarts are impregnated with falt, and the greater part of the fprings in thefe defarts are fo faline, that it is not poffible to drink the water. To the fouth of Abyffinia, at the feet of the mountains which feparate that country from that of the Gallas negroes, falt exifts in dry and folid maffes. The fummit of the mountains which border the defart to the weft of Cairo, prefents an immenfe plain covered with a mafs of falt. According to Horneman it is fpread over fo large a track of furface, that no eye can reach its termination in one direction; its breadth extends feveral miles. To the weft of the defart of Sahara are the great falt rocks of Tegaza, on the fouth-eaft frontier of the defart of Zuenziga, a little diftance from Cape Blanc. They are worked by the Moors. Thefe falt mines furnifh the white and coloured falt, which is carried by caravans to Cafnah and Tombuctoo, to fupply the Negro ftates; for it does not appear that there are any falt mines in Negro land properly called. The mines of falt fpread in that part of Africa which the ancients called Libya, have been well indicated by Herodotus, and it is in this country that he has defcribed buildings conftructed of rock-falt, like thofe in Caramania and Arabia. Other falt mines, according to Park, are found on the fouthern frontier of the great defart Sahara. Their produce is alfo fold to the Negroes on the borders of the Niger and the Jolibe. In the kingdom of Tunis, mount Had Delfa is entirely compofed of very compact falt of a red and violet colour. The lake des Marques, and the plains near it, alfo contain much falt. There are mines of rock-falt in the country of Bamba, in the kingdom of Congo. On all the weftern coaft of Africa there are falt lakes and marfhes. In the neighbourhood of the Cape of Good Hope, and in Caffraria, rock-falt is lefs common; but there are falt lakes to the eaft of the Cape, on the frontiers of Caffraria, which contain at the bottom beds of falt varioufly coloured.

Salt lakes exift in the Cape Verde iflands, and natural falt-marfhes, particularly in Bona Vifta.

Spain is the only country in the fouth of Europe which contains extenfive repofitories of rock-falt in confiderable maffes above the furface. It is found there in elevated fituations, forming entire hills: brine-fprings alfo iffue from the feet of the mountains which traverfe that country. According to the defcription of Mr. Bowles, the repofitory of rock-falt which lies between Caparofo and the river Ebro, is in a chain of hills which extend from eaft to weft. Thefe hills are compofed of lime-ftone, mingled with gypfum, the chain extending more than two leagues. In the moft elevated part is fituated the village of Valtierra, on a flope towards the middle of which is found a bed of rock-falt. It may be about 400 paces long, and 80 wide. The falt is contained in a bed of about five feet in thicknefs.

"I examined," he adds, "with attention thofe beds of falt; I compared them with the layers of earth and gypfum in which it is imbedded; I found the outfide layer to be compofed of gypfum; and, immediately afterwards, I met with

two inches of white falt, fucceeded by two inches of ftony falt, and a layer of earth. I found others alternately compofed of earth and falt to the very bottom of the mine, which is of gypfum, undulated like the other layers. The layers of faline rock are of a dufky blue, thofe of falt are white.

"This mine is confiderably elevated above the fea, for you afcend continually all the way from Bayonne.

"The fecond hill is that of Cardona, in Catalonia, near the mountain of Montferrat, fixteen leagues to the N.W. of Barcelona, and a few leagues from the Pyrenees.

"The village of Cardona is fituated at the foot of a rock of falt, which, from the fides of the river Cardonere, feems nearly mural. This rock is a block of maffive falt, which rifes from the earth about four or five hundred feet, without crevices, chafms, or layers. No gypfum is found near it. This block is about a league in circumference; and its elevation is equal to that of the furrounding mountains: as its depth is not known, it is impoffible to fay on what it refts.

"In general, the falt, from the top to the bottom, is white, though fome parts are red; fome is alfo found of a fine blue. There are alfo in Spain other repofitories of rock-falt and faline fprings. In La Mancha, at Almengranilla, there is a mafs of falt fimilar to that of Cardona; it is feventy yards in diameter, mixed with fulphate of lime, and covered with the fame ftone, including cryftals of red quartz; above which are filiceous pudding-ftones, and a ftratum of carbonate of lime."

The mines of rock-falt that are wrought at Poza, near Burgos, in Caftille, are remarkably fituated, being placed in a vaft crater. A French traveller, M. Fernandez, found pumice-ftones, puzzolana, and other volcanic productions there.

Rock-falt is likewife found near Aranjuez and Ocanna, in the tranfition hills between Sierra Morena and Madrid.

On the north fide of the Pyrenées no beds of rock-falt have been difcovered, but numerous brine-fprings occur, particularly at Salies: in the department of the Lower Pyrenées the foil is calcareous, and fulphate of lime is found in the neighbourhood of the fpring.

There are falt-fprings at Salies, to the fouth of Thouloufe, alfo at Salins and Montmorat, in the department of the Jura; in the firft of thefe the water contains fifteen *per cent.* of falt.

There are about twenty brine-fprings in the department of La Meurthe, which contain, on the average, thirteen *per cent.* of falt. Thefe fprings are at no great diftance from each other; fome are at the foot of the chain of Jura, the others at the foot of the Vofges: the product of thefe brine-fprings fupplies Switzerland with falt. There are falt-fprings in the department of Mont Blanc, in the midft of the Higher Alps. In the fame department, near St. Maurice, there is a falt-rock near the region of perpetual fnow, which is probably the higheft fituation in Europe where this mineral occurs. The rock confifts of gypfum, intermixed or impregnated with falt, which is extracted by folution in water; the infoluble part remains porous and light. Various brine-fprings alfo occur in other parts of France.

Though there are numerous brine-fprings in the north of Germany, no beds of rock-falt appear on the furface, until we approach the circle of Auftria and the neighbouring countries. The range of falt-rocks commences at Halle, in the Tyrol, paffes through Reichenthal in Bavaria, and continues to Hallein in Salzburgh, Hallftadt, Ifchel, and Ebenfel, in Auftria, and terminates at Auffe in Styria. The falt at Halle is worked in a peculiar manner: parallel galleries are run into the rock, in thefe dykes are formed, and water is let into them, where it remains from five to twelve months. When the water is faturated, it is drawn off in pipes, and the folution is evaporated.

On comparing the geological fituation of the greater part of the beds of rock-falt and brine-fprings, it will be feen that they occur moft frequently at the foot of high mountainous chains. The mines of rock-falt in Tranfylvania, Upper Hungary, Moldavia, and Poland, may be cited in further proof of this. Thefe mines are numerous, and very important from their extent, and the vaft maffes of falt they contain. They are found along the chain of the Carpathian mountains, and fpread nearly in an equal degree on each fide of the chain accompanying thefe mountains to the extent of more than two hundred leagues, from Wieliczka in Poland, towards the north, to Fokfzian or Rymnick in Moldavia, to the fouth.

The ftrip of land that contains the falt-rock or brine-fprings, is near forty leagues broad in fome parts. In it may be reckoned about fixteen mines, that are worked for falt; forty-three indications of mines that have never been wrought; and four hundred and twenty, or four hundred and thirty, brine-fprings.

The moft remarkable of thefe commence in the north-eaft, and extend in a foutherly direction, including thofe of Wieliczka, Bochnia, and Samber, in Poland; and fome brine-fprings in Buchovina and Moldavia, particularly near Ockna. On the fouth-weft of the chain, following the fame direction, are thofe of Sowar, near Eperies, in Upper Hungary; of Marmarofch, in Hungary; of Dees, Torda, Paraid, and Vifackna, near Hermanftadt, in Tranfylvania, &c.

The falt-mines of Wieliczka, near Cracow, and thofe of Bothnia, which appear to be a branch of them, have become celebrated from the accounts given of them by almoft every traveller who has vifited that country; many of their defcriptions are too highly coloured. They are, indeed, very ancient, having been worked ever fince the year 1251; but have nothing to diftinguifh them above others, except the extent of the works in the beds of rock-falt, the dimenfions of which ftill remain unknown. The ground that covers the rock-falt is compofed, like that over moft other falt-mines, of alternate ftrata of fand, pebbles, and marle, including large blocks of falt. You go down to thefe mines by fix fhafts, of four or five yards in diameter. Various ftructures have been formed in the body of the falt itfelf. We find there a ftable, chambers, and chapels, all the parts of which, as pillars, altars, and ftatues, are of falt. The fhafts and galleries are perfectly dry, fo that you are more incommoded by duft than dirt. There are fprings, however, both of falt water and of frefh in thefe mines. It appears that the air is not fo foul in them as in moft falt mines; but the workmen do not refide in them, as fome have afferted. In certain parts of the mine, hydrogen gas fometimes collects and explodes.

The falt is cut out in little afcending fteps. It is formed into parallelepipedons, weighing about eighty or a hundred pounds, or into cylinders, which are put into cafks. This mine produces about fix thoufand tons of falt every year.

According to the defcription of Dr. Townfon, the falt in the upper mines does not form continuous ftrata, or rocks, but exifts in immenfe detached blocks or maffes, imbedded in marle. He gives the following account of the ftrata which cover the falt.

	Yards.
Vegetable soil - - - - - -	4
Sandy clay - - - - - -	10
Fine sand effervescing with acids - -	7
Marle with sand, containing fragments of sand-stone	18
Sand-stone - - - - - - -	2
Marle mixed with salt, in small particles and cubes	40

At the depth of forty yards in this marle the salt is found. The blocks of this mineral are of such a size, that in passing through the galleries formed in them, sometimes the upper, and sometimes the lower end only of a block may be seen; but often, though the galleries are three or four yards high, the breadth can only be observed, and even in some places the blocks of salt form the sides of the gallery for fifteen or twenty yards. These blocks compose the upper bed of salt, and from them the whole of what is called the green salt is obtained. This salt, which is of a greenish or blackish hue, owes its colour to numerous fine particles of a substance which seems to be of the nature of argillaceous schistus scattered through it. This variety of salt, on account of its impurity, is retained in the country for home consumption. In this marle, also, blocks of sand-stone are sometimes found imbedded, and the marle itself is strongly impregnated with salt. Lower down there is another bed of salt, called szybicker salt, which is in some places two or three yards thick; it is of a purer quality than the former, and is exported to foreign countries. This variety of salt-rock is disposed in very extensive beds. The mine has been driven in one place twelve hundred yards, from east to west, and four hundred from north to south; salt being still found there. The utmost extent is yet unknown. The nature of the stratum beneath the szybicker salt has not been ascertained; for the miners, being apprehensive of increasing the quantity of water, have never proceeded to a great depth in this stratum. The greatest depth of the mine is two hundred and forty yards. It does not appear that the remains of organized bodies have been found in great abundance in the strata connected with the salt-rocks now described. None have been observed, according to Dr. Townson's information, in the szybicker salt, or the lower strata; but some have been seen in the marle which envelopes the block of green salt; such as bivalve shells, at the depth of seventy-two yards; crabs' claws, at the depth of eighty yards; and charred coal, mixed with salt and gypsum, at the great depth of two hundred yards.

From the circumstance of mass being formerly celebrated in these mines two or three times a week, it has been said that the workmen, to the amount of five hundred, live constantly below ground. They do not, however, continue longer than their hours of working. To keep the mines dry, the salt water is drawn up in leathern sacks, and is thrown away; the small quantity of fresh water which they afford is reserved for the use of the horses which are employed in the subterraneous operations. At the time Mr. Townson visited them, twenty-four horses were constantly kept below ground.

In the mine of Bochnia the salt presents itself in a stratum at once, and not in detached pieces. The strata of clay, as well as those of salt, are undulated, and not of an uniform thickness. The salt is sometimes brown, at others reddish, and at others transparent. The different coloured salt is not arranged in parallel layers. The strata dip at an angle of about forty degrees with the horizon. Dr. Townson informs us that very beautiful specimens of fibrous muriate of soda are found in it.

At Thorda the mass of salt is divided into horizontal but undulated strata. These strata are about eight or ten inches thick. The lowest are the most undulated.

Near Ockna, in Moldavia, there is a hill of rock-salt, in many parts of which the salt appears exposed to view.

The mines on the south-east of the Carpathian chain appear more numerous, and are dispersed through a greater space of ground than those on the north-east. They are in general very near the surface. Some of those in Transylvania are so to such a degree, that persons are appointed to cover the salt with turf, when it is washed bare by the rain. These masses, however, are so thick, that their bottom has never been found. They are not worked to the depth of more than a hundred and seventy or eighty yards, because the extraction of the salt becomes then too expensive. In the county of Marmarosch they have been wrought to the depth of upward of two hundred yards. These mines contain likewise a great deal of petroleum, and the ground in which they are contained is every where furrowed by rivers. The mud interposed between the water of these and the salt, is imagined to prevent the salt from being dissolved by them.

At Paraid, in Transylvania, there is a valley, the bottom and sides of which are of pure salt. Walls of salt appear there sixty or seventy yards high.

The mine of Eperies is three hundred and sixty yards deep.

In the salt mines of Marmarosch, water has been found included in the substance of the salt-rock.

The mines of the south-west of the Carpathian mountains are generally wrought by means of shafts. There are at least two to each mine; one for the workmen, the other for drawing up the salt. The salt is cut out in ascending steps, which produces empty spaces, of a conical form, in the midst of the strata. The ladders reach perpendicularly to the bottom of this conical space: so that within it they stand perfectly detached. Thus the greater part of the body of salt is extracted, leaving empty spaces, which are conical, and which communicate with one another by means of galleries. It has been thought, that, in order to leave less salt, it would be better to give these spaces the shape of a parabola. The salt is so plentiful, that the miners are paid only for such pieces as weigh upwards of eighty pounds, the others being rejected as useless. When the workmen are incommoded by water, it is drawn up in leathern bags, to be emptied out of the mine.

The Transylvanians and Moldavians extract salt from their brine-springs, by throwing the water on wood fires, as the Gauls and Germans did in former times.

No salt-mine, or brine-spring, is known either in Sweden, or in Norway.

There are a great number of both, and particularly of salt lakes, in Russia. Among these is the salt lake of Tor, towards the northern extremity of Little Tartary.

There are similar salt lakes in the Crimea.

At Balachna, on the banks of the Wolga, are some very rich brine-springs.

In Russia, in Asia, we find the brine-springs of Permia, of which there are a great number at the foot of the mountains of Poyas.

About eighty versts from Yena Tayeoska, in the desart between the Wolga and the Uralian mountains, there is a mine of rock-salt.

In the government of Astracan, to the north of the Caspian sea, in the environs of Orenburgh, and in the country of the Bashkirians, salt lakes are very common, and the water evaporating during the summer, the salt

appears cryſtallized on their ſurface, and round their borders. When this water is highly concentrated, it has a deep red colour. The ſalt formed in them has often the ſame hue; and when this is the caſe, it diffuſes a very perceptible violet ſmell.

One of theſe is the ſalt lake of Elton, above Aſtracan, in the re-entering angle formed by the Wolga. The Kalmucks called it the Golden lake, becauſe of its red appearance, when the ſun ſhines on it.

The lake of Bogdo, ſituate near this, yields a perfectly white ſalt, free from ſulphate of magneſia, and preferred to that of lake Elton.

Near Aſtracan, too, is the mine of Iletzki, celebrated for the quantity of ſalt it furniſhes. The ſalt lies at no great depth, and reſts on a very hard clay. The ſoil above it is ſandy, and full of holes, containing water ſaturated with ſalt.

In Siberia there is a mine of rock-ſalt on the right bank of the Kaptendoi; and on that of the Kawda are fourteen brine-ſprings. Others are found in the government of Kolivan, and in the environs of Irkutſk, near the lake Baikal, in the centre of Aſiatic Ruſſia. Laſtly, the country near the Caſpian ſea is ſo impregnated with muriate of ſoda, that in the environs of Gourief, the fogs and dew that ſettle on people's clothes, and on plants, are ſaline. Pallas.

Among the Mongul Tartars, the ſoil is ſo thoroughly penetrated with muriate of ſoda, that the people lixiviate it, and evaporate the ſolution to obtain ſalt.

That part of China, which borders on Tartary, contains ſalt-mines, and the ground is ſtrongly impregnated with ſalt.

Salt is found in the ſame manner throughout almoſt the whole table-land of Great Tartary, Thibet, Hindooſtan, and particularly Perſia, where very extenſive plains are ſeen covered with a ſaline efflor eſcence. The iſle of Ormus, at the mouth of the Perſian gulf, appears, according to the accounts of travellers, to be one large rock of ſalt. This ſubſtance is alſo found in ſolid maſſes near Balach, on the eaſtern ſide of Perſia. In the deſart of Caramania, according to Chardin, rock-ſalt is ſo abundant, and the atmoſphere ſo dry, that the inhabitants uſe it for building their houſes. It is found in the neighbourhood of Iſpahan, and in the mountains to the north of that city.

The repoſitories of rock-ſalt in America are leſs known. According to Ulloa and others, it is found in vaſt quantities in the elevated deſarts of Peru, at the extraordinary height of 10,000 feet, or more, above the preſent level of the ſea. It is extremely hard, forming ſolid continuous rocks of a dull violet colour.

The mountain of Xaragua, in the iſland of St. Domingo, affords ſalt; and in the ſame iſland there is a very remarkable ſalt lake, about 22 leagues in circumference, called Henriquelle. The water, which is inhabited by lizards, alligators, and land-tortoiſes, all of a large ſize, is deep, clear, bitter, ſalt, and of a diſagreeable ſmell. Near the middle of the lake is an iſland, about ſix miles long and three broad, well ſtocked with goats, whence it has the name of Cabrito iſland; and in this iſland is a ſpring of freſh water.

Salt lakes occur in other of the Weſt India iſlands. In North America, weſt of the Alleghany mountains, in the ſtate of Kentucky, are numerous repoſitories of rock-ſalt and brine-ſprings: theſe are called *licks*, where the elks and buffaloes formerly repaired in herds, to lick the ſoil impregnated with rock-ſalt. On the weſtern ſide of the great river Miſſouri, a chain of mountains extends 80 miles in length, and 45 in breadth, and of conſiderable height: it conſiſts of pure rock-ſalt, barely covered with earth, but without any tree or ſhrub. Further weſt, in California, ſalt is found in a very pure ſtate, in large and ſolid maſſes.

From the preceding account it will be ſeen that this moſt uſeful mineral is found in every quarter of the globe; and in many parts it exiſts in maſſes of immenſe ſize and extent, compared with the rock-ſalt in our own iſland, in the county of Cheſter. Such, however, is the ſuperior induſtry of our inhabitants, that the quantity annually exported from that county alone greatly exceeds that procured from any other diſtrict in the known world, being not leſs than 140,000 tons, the produce of the ſalt-rock and brine-ſpring; while the celebrated mines at Wieliczka, in Poland, are ſtated to yield only about 6000 or 7000 tons. Where rock-ſalt is white or colourleſs, it is immediately applicable to all uſeful purpoſes; but when mixed with earthy matter, it is rendered pure by the ſimple proceſs of ſolution in water. The liquor is afterwards drawn off into pans, leaving the inſoluble part behind; and the water is then evaporated either by the natural warmth of the climate, or by fires. See SALT.

ROCK-*Salt*, in *Rural Economy*, that ſort of foſſile, rocky, ſaline material, which is dug out of the bowels of the earth, from different depths, in ſome parts of this and other countries, where it exiſts in layers of different thickneſſes. The beds of this kind of ſalt, which are found in the county of Cheſter, are highly intereſting and important to the country, whether conſidered as affording an article of manufacture and commerce, or as forming a ſource of revenue. The diſcovery of the beds or ſtrata of this ſort of matter, in this diſtrict, is, however, of no very remote date, as will be ſeen under the head of ROCK-*Salt Pits*; but the layers are pretty numerous, and of conſiderable extent, differing greatly in their purity, though, in many inſtances, requiring a greater or leſs degree of preparation before the ſalt can be uſed.

It is remarked by the writer of the account of the Agriculture of Cheſhire, that, from ſome experiments made on different ſpecimens of rock-ſalt, it would appear that the tranſparent kind of it is an almoſt pure muriate of ſoda, which contains no admixture of either earth or earthy ſalts; and that the colour of the leſs tranſparent and brown ſpecimens is derived from the earth that enters, in greater or leſs proportions, into their compoſitions. That on 480 grains of tranſparent rock-ſalt being diſſolved in four ounces of diſtilled water, there was, firſt, no precipitate let fall, on the addition of carbonate of potaſh. Secondly, no alteration was produced by this ſolution on blue vegetable juices. Thirdly, on the addition of a few drops of tincture of galls, a ſlight purple tinge was given to the ſolution; and after ſtanding ſome hours, there was a brown ſediment at the bottom of the veſſel. Fourthly, on the addition of muriate of barytes, there was no precipitate thrown down. From the firſt of theſe trials, it is ſuppoſed that rock-ſalt has no muriate of lime, or muriate of magneſia, combined with it; from the ſecond, that it has no uncombined acid or alkali; from the third, that it contains ſome portion of iron; and from the fourth, or laſt, that there is no ſulphate of lime contained in it.

And that, on examining different ſpecimens of the leſs tranſparent, and the brown rock-ſalt, with the ſame reagents as in the above trials, it was found that theſe conſiſted of muriate of ſoda, or ſea-ſalt, in combination with a certain proportion of earth, varying in quantity from one to thirty *per cent.*; alſo, that the earth was wholly the argillaceous or common clay; but that ſome of the ſpecimens contained a few grains of ſulphate of lime, in 480 of thoſe of the rock-ſalt.

The beds of this ſalt are now well known to be the prin-

cipal cause of the salt-brine springs in this county; and, in connection with some other circumstances, to have a great share in causing the vast differences in their strength, in different places. See SALT-*Brine Springs*.

This is a strong sort of salt, which is found useful for a variety of domestic purposes, according to the different manner in which it is prepared, or the difference in the size of the particles or crystals of which it is composed, as will be more fully shewn under the head SALT.

Although rock-salt is found in various parts of the above district, there are no pits of it wrought at present, except in the vicinity of Northwich. And part of the inferior rock-salt, which is procured there, is, it is said, used at some of the refineries in that neighbourhood; and a further quantity sent down the river Weaver, for the supply of the refineries at Frodsham, in the same county, and those on the banks of the Mersey, in Lancashire. The purer rock-salt, or that which is called in general Prussian rock, is carried by the same conveyance to the port of Liverpool; whence, according to the above writer, it is exported chiefly to Ireland, and the ports of the Baltic. The annual quantity of rock-salt sent down the first of the above rivers is found, on the average of the last ten years, to be 51,109 tons. But in this, it is observed, is included what is used at the Frodsham and Lancashire refineries, which may probably be about one-third of the whole. And it is added, that it appears, from the report of the committee of the house of commons, appointed to inquire into the laws respecting the salt duties, printed in June 1801, that,

$$\left.\begin{array}{l}\text{in } 1798\\ 1799\\ 1800\end{array}\right\}\text{ were exported }\left\{\begin{array}{l}20{,}162\\ 33{,}913\\ 34{,}939\end{array}\right\}\text{ tons of rock-salt.}$$

Of this quantity,

$$\begin{array}{ll}\text{in } 1798, & 16{,}095\\ 1799, & 22{,}374\\ 1800, & 19{,}663\end{array}\Bigg\}\text{ tons}$$

were sent to different ports in Ireland: the remainder was principally exported to Denmark, Russia, Sweden, Prussia, and Germany. However, a small quantity went to Guernsey, Jersey, and the West Indies.

This shews, in a striking manner, the great utility and advantage of this article in a manufacturing and trading point of view, as well as in other ways.

In regard to the original formation of the beds or strata of rock-salt, in this and other countries, different theories, opinions, and conjectures, have been formed and proposed; but it is one of those geological questions which is extremely embarrassing in its nature, and very difficult in its solution. Mr. Holland has, however, in the above work, ingeniously stated several suppositions on the subject, and the objections to which they are exposed. It is remarked, that wherever rock-salt is met with, sulphate of lime seems to be very generally discovered in mixture with the earthy strata above it. And the writer of the "Memoire sur le Ser Marin," in the 11th volume of the Annals of Chemistry, it is added, informs us, that this is the case in Poland, Transylvania, and Hungary; also, that there is commonly a layer of gypsum betwixt the strata of stone and the bed of salt. This gypseous layer is of different colours, and is found crystallized, striated, and mixed with marine shells. The gypsum above the beds of rock-salt in Cheshire is, in like manner, found crystallized and striated; but no marine exuviæ, or organic remains, it is observed, are ever met with in any of the strata. Nor does gypsum accompany it, as is usual in other places, as near Cordova, in Spain, where rock-salt forms a mountain 500 feet in height, and three miles in circumference, as noticed by Kirwan and Townshend. Jars, the author of the "Voyages Metallurgiques," who, it is asserted, has given the most particular account we have of the upper stratum of rocksalt about Northwich, remarks, that "it appears to have been deposited by layers or beds of several colours;" and that "these layers of salt are in such a position, as to lead us to believe that the deposition of it was made in waves, similar to those which are formed on the sea-coast."

This, Mr. Holland says, coincides with an opinion suggested by Mr. Stanley, a friend of his, in regard to the probable origin of the beds of rock-salt, now in existence in this district; who states that rock-salt is there found in several strata, one above the other, with intermediate beds of indurated clay, in the vallies of the Weaver, and those of the other rivers and brooks emptying themselves into it; but that it has never been found so near the surface, as to be above the level of the sea, or beneath any solid rock. If beds of rock-salt are to be considered as so many deposits of salt from sea-water, we must suppose the sea, at some former period, to have occupied the vallies in this county; and that, from time to time, the communications were interrupted between these vallies (then deeper than they are now) and the sea. Earthquakes, or accumulations of sand in the estuaries of the Mersey and the Dee, might, it is contended, have caused the interruptions. Whenever the sea-water in the vallies became separated from the sea, the salt contained in it would subside, by the natural process of evaporation. This, it is supposed, would the more easily have taken place, if, by any subterraneous fermentation, the ground below the water should have been heated. To account for a greater accumulation of salt than the sea-water filling all the lowest parts of the district would contain, we must suppose, it is said, that the obstruction interposed between the vallies and the sea had been repeatedly broken down, and renewed again. Tides, unusually high, might occasionally overcome the resistance of the accumulated sand; and if the intervals between the inundations were only of short duration, a subsidence of salt might take place, equal to the formation of the thickest stratum of the rock-salt now existing. Long intervals between the inundations would admit of an accumulation of clay, and other earthy particles, over the salt thus deposited; and in this manner would be formed a new basis for another stratum of rock-salt to repose upon. Thus, it is thought, the regular and astonishing existence of the salt strata may be accounted for, without necessarily supposing them coeval with the original formation of the earth: but to confirm the theory, it is suggested that much observation and close inquiry into the natural history of the county would be required.

Mr. Holland, however, justly thinks that there are many objections to the theory which supposes the beds of rock salt, in this district, to have been formed by deposition from the waters of the sea; some of which he states rather for the sake of promoting discussion and inquiry, than of affording any very decided opinion on a matter of so much doubt, uncertainty, and obscurity. Though on making a perpendicular section of the upper bed of rock-salt, an irregular stratification, such as noticed by Jars, may, he says, by frequent accurate examination, be observed, the general appearance of the sides of the openings, whence the rock-salt is taken, is that of a confused and irregular red mass; in which some portions of salt have a greater, others a less, proportionate admixture of earth; while, here and there, they may be seen perfectly pure and transparent. He, therefore, asks, is it likely that this irregularity and confu-

tion would have existed, had the beds of rock-salt in this district been formed by the evaporation of sea-water inundating the land at certain intervals of time, as the above theory supposes? On the contrary, says he, would it not be natural to expect from reasonings, *à priori*, that the salt, thus deposited from sea-water, would be disposed in layers perfectly regular, and differing from one another merely in thickness, or a few other circumstances of inferior moment?

Another fact which, it is supposed, invalidates, in some measure, the notion that the rock-salt has been deposited from the waters of the sea, is the great disproportion of quantity, shewn by analysis to exist, between the earthy salts contained in the brine of this district, and those held in solution by sea-water; the ratio here being as one to ten, or the proportion which the earthy salts bear to the pure muriate of soda in sea-water is ten times greater than that which prevails in the Cheshire brine. The ascertaining of this fact proves, it is supposed, that the rock-salt (from the solution of which the brine is formed) is combined with a much smaller proportion of earthy salts than exists in sea-water; a circumstance difficult to be accounted for, on the supposition that the beds of this substance were formed by the evaporation of the sea-water, occupying the vallies and lowest parts of the land. It must be noticed, however, as worthy of attention, that the earthy salts, intermixed with the rock-salt in the above district, are the same which are held in solution by sea-water, being principally muriated magnesia and sulphate of lime.

There is, however, a still stronger proof, it is supposed, against the notion that the beds of rock-salt in this county are depositions from the sea-water, in the circumstance that no marine exuviæ have ever been discovered in the strata. This, it is imagined, would almost indubitably have been the case, had the land been covered with sea-water during a period of sufficient length for the deposition of beds of salt of such prodigious thickness; and the fact, that no such exuviæ do actually exist, is supposed in itself sufficient to induce a suspicion that the theory in question cannot be well founded. Other objections too, it is observed, offer themselves to its validity; such as the enormous depth of sea-water necessary to the production of a body of rock-salt forty yards in thickness; the difficulty, if not impossibility, on such principles, of accounting for the formation of the singular insulated mountain of rock-salt at Cordova, in Spain; with others of a more trivial nature, which will readily present themselves in this inquiry.

It is, however, at the same time candidly acknowledged, that there are many facts and circumstances of actual observation, that confer a strong degree of plausibility on the opinion, against which it has been contended. The certainty that the surface of the county was at some former period much lower than it is at present, and the diminution of the thickness of the strata of rock-salt in proportion as they recede from the sea, are circumstances which undoubtedly range themselves on this side of the question: and, upon the whole, it is thought, that it may be doubted whether the theory, which regards the beds of rock-salt as deposits from sea-water, does not accord more exactly with existing appearances, than any other which has been adduced on the matter.

It is supposed that many things, which at first seem objections, may be obviated by a reference to the principles of the Huttonian theory of the earth, and the excellent illustrations of it by professor Playfair. However, in the present state of our knowledge, any opinion formed on the matter must, it is imagined, from its very nature, be purely theoretical. See Rock-*Salt Pits*.

Rock-*Salt Pits*, such pits, shafts, mines, or openings, as are dug or made in any other manner in the ground, for the purpose of getting and raising rock-salt from them. Pits of this sort are met with in many parts of the county of Chester, which are wrought to very considerable extents, and are of great importance to the interests of the district in many different ways, as well as to the nation in general, as may be seen under the head Rock-*Salt*.

According to the statement of Mr. Holland, in his Agricultural Survey of the above county, the first bed and pit of salt-rock was found and wrought in Marbury, at a small distance from the town of Northwich, at the depth of about thirty yards from the surface, in the year 1670, when searching for coal. The bed was thirty yards in thickness, and rested upon a stratum or layer of hard clay. In consequence of this discovery, other similar attempts were made; and on sinking shafts or pits any where in the vicinity of it within the space of half a mile, it was found to exist at about the same depth from the surface of the earth, when not prevented from being dug down to by brine-springs or those of common water. This continued the only place in which it was found until the year 1779, when this sort of rock was again met with in searching for brine in the neighbourhood of Lawton, at the depth of about forty-two yards, but only of the thickness of about four feet; there being beneath it a bed of indurated clay ten yards in thickness, which being penetrated through, a second stratum of rock-salt was discovered twelve feet in thickness; and on continuing the sinking of the pit, another layer of indurated clay, fifteen yards in thickness, was passed through; below which appeared a third stratum of rock-salt, which was sunk into not less than twenty-four yards; the lowest fourteen yards, being the purest, or the least mixed with other substances, were the only parts that were wrought.

Until this period, in the neighbourhood of Northwich, no attempts had, however, been made to sink pits in order to find a lower stratum of rock-salt; as the one which had been first met with was so thick, and furnished such an abundant supply for every demand, there could be no other inducement to this than the expectation of meeting with a stratum, at a greater depth, which might contain a less admixture of earthy matters. It would seem, too, that the fear of meeting with springs below, which might impede the working out of the materials from the pits, and even render this wholly impracticable, prevented the proprietors of them from sinking deeper. As, however, no inconvenience or interruption of this nature had occurred, on sinking through different alternate strata of rock-salt and clay at Lawton; and it had been found that there was a lower stratum of rock-salt there, which was more pure than those nearer the surface, the owners of one of the works or pits in this vicinity were induced, a little time after the trials at Lawton, as in 1781, to sink deeper than had yet been done, and to pass through the bed or body of indurated clay lying underneath the rock-salt, which had been so long known and wrought. This indurated clayey material was found to be from ten to eleven yards in thickness; and immediately beneath it a second stratum of rock-salt was met with, the upper part of which differed little in purity from that of the higher stratum or layer of rock; but on penetrating into it to the extent of from twenty to twenty-five yards, it was there found to be much more pure and free from earthy admix-

ture. But it continued to have this increafed degree of purity for four or five yards only; while, for fourteen yards ftill lower, to which depth the pit or fhaft was funk, the proportion of earthy matter was again as large as in the upper part of the ftratum. It was therefore, on this account, thought ufelefs to fink the pit to any greater depth. Many other proprietors of pits, fhafts, or mines, in the fame neighbourhood, it is ftated, followed the example which had been thus fet them; and penetrated through the bed of indurated clay lying beneath the upper ftratum of rock-falt. A fecond ftratum of rock-falt was conftantly met with below this; and on paffing down into it, the fame order of difpofition as to purity was obferved, as in the pit or mine in which it had been firft noticed and examined; and the fame has been found to prevail in all the pits, fhafts, works, and mines, which have fince been funk in the fame vicinity.

It is further noticed, that there is great uniformity in the ftrata which are paffed through in finking pits for rock-falt or brine; and that they very generally confift of clay and fulphate of lime mixed in various proportions; that of the latter fomewhat increafing as the pit, fhaft, or work approaches the rock or brine. The workmen diftinguifh the clay by the appellation of *metal*, giving it the name of red, brown, or blue metal, according to its colour; and the fulphate of lime by that of *plaifter*. See Quarry.

The ftrata formed by thefe are, in general, clofe and compact; allowing very little frefh water to pafs through them. In fome places, however, they are broken and porous: and they admit fo much frefh water into the pit or work, that whenever they have been met with, it has been ufual to difcontinue any attempts to pafs through them in finking the pits. In thefe places the workmen call the metal *faggy*. It was thought not only impracticable to overcome a water, which vulgar prejudice had magnified into a great ftream running under ground; but it was believed, even if the finking could be continued below this, that the water could not be kept out of the pit, fhaft, or work, and that it would either weaken the brine fo as to deftroy its value, or would find its way into the cavity of any rock, pit, or mine which might be found below it. Later experience, it is faid, has proved, that thefe ideas were not altogether well founded. A few years ago an attempt was made in Witton to pafs through this porous ftratum, in order to get to the brine. It was met with about twenty-eight yards from the furface; the thicknefs of it was about thirteen feet; and the quantity of water, which was forced through it into the pit or fhaft, was three hundred and fixty gallons a minute. By means of a fteam-engine, the finkers were enabled to pafs through this water; to fix a gauge or curb a few yards below it, in a ftratum of indurated clay; and thence to bring up a wooden frame, fupporting a wall of puddled earth twelve inches thick, by which the accefs of the frefh water into the pit or fhaft was in a great degree prevented, and an opportunity given to pafs down to the brine below. A fhaft was afterwards funk through this porous ftratum, for the purpofe of obtaining rock-falt; which object was, after a fhort time, defeated, by the influx of brine into the fhaft at the furface of the upper ftratum of rock-falt; an accident originating in a caufe completely diftinct from the frefh water in the porous ftratum or bed. An exact fection of the different ftrata funk through in reaching the fecond bed of rock-falt in the pit at Witton, near Northwich, is given by Mr. Holland in the above report; and all the ftrata in the neighbourhood of the laft town are fuppofed to have nearly a fimilar difpofition. The inclination of them in the pit or fhaft at the above place was from north-weft to fouth-eaft; and the dip about one yard in nine. The ftratum through which the frefh water flowed is fhewn, and the level it found, it is faid, was fixteen yards from the furface, which, it is remarked, nearly correfponds with that of the brook below. The line of feparation between the loweft ftratum of earth, and the firft of rock-falt, is very exactly defined; they are perfectly diftinct, and do not at all run into each other. It is farther noticed, that in carrying a horizontal tunnel for one hundred yards along the upper ftratum of rock-falt, this was found to be irregular and unequal on its furface; the irregularities in a great meafure correfponding with thofe on the furface of the ground above.

The higheft bed or body of rock-falt in the pits near Northwich is the thickeft in thofe fituated the moft to the north-eaft, gradually declining in thicknefs towards the fouth-weft, fo as to lofe one-fixth of it in the courfe of about a mile. It decreafes from about thirty yards in thofe the fartheft to the north-eaft, to about twenty-five in that the moft to the fouth-weft.

A fingular appearance is remarked to prefent itfelf on making a horizontal fection of the ftratum of rock-falt in the pits: on the whole of the furface made by fuch a fection, various figures, it is faid, may be obferved, differing in form and fize, fome of them being nearly circular, others approaching more to an oval form, while in many an irregular pentagon may be traced. Some of them are not more than two or three feet in diameter; others are ten or twelve feet. The lines which form the boundaries of thefe figures are white, and from two to five or fix inches wide. On examining thefe appearances, they are found, it is faid, to be owing to the rock-falt, in the white lines forming the divifions of the figures, being perfectly pure, and free from earthy admixture. When combined with the falt, having earth in various proportions mixed with it, a general effect is produced, it is faid, not very diftantly refembling mofaic work. This difpofition is uniformly obferved, it is faid, throughout the whole thicknefs of the ftratum of rock-falt; and that in whatever part of it fuch a fection as the above is made, fimilar appearances are met with. To what caufe it has been owing that the rock-falt has been depofited in this fingular manner, it is thought difficult to conceive. The whole ftratum of rock-falt may, it is fuppofed, be compared to a mafs of bafaltic columns; the lines of feparation in each pillar being marked by the pure and tranfparent white falt. Thefe appearances, it is noticed, afford feveral grounds for inferences favourable to the theory of the earth mentioned under the head rock-falt, to the illuftrator of it. See Rock-*Salt*.

It is likewife further obferved, that the divifion betwixt the lower portion of the upper bed of rock-falt, and the indurated clay or ftone beneath it, in pits of this kind, is as exactly defined, as that between the upper portion of it and the earth above. That in paffing through this ftone fmall veins of rock-falt are met with, here and there running in it, in various directions; and that wherever there has been any little crevice in it, it is found filled up with rock-falt, to which the clay and oxyd of iron have given a deep red tinge. The thicknefs of this ftratum of ftone is faid to be uniformly found to be from ten to eleven yards; and the lower part of it is as diftinct from the fecond bed of rock-falt, as its upper part is from the firft: alfo that its termination is equally abrupt or fudden.

And that the perpendicular section of the second bed of rock-salt varies little from that of the upper bed, till it has been penetrated about twenty yards from the surface, when it assumes a more stratified appearance, and is here found, as already noticed, to have a much smaller proportion of earth combined with the muriate of soda. A section of this stratum, similar to the above, displays the same figured appearance in the roof of the pit, as that of the upper stratum.

In the very instructive report mentioned above, the writer has given a coloured representation of the roofing of a rock-salt pit, and another of the part where the lower surface of the upper bed of rock-salt joins the inferior clayey or other strata. These, as well as other matters in that work, are particularly worthy of the attention of the inquirer on this subject.

But though beds of this sort of material have been occasionally met with in some other parts of the same district, they have not been wrought, principally on account of the want of water carriage: as the working of those pits at Lawton was soon discontinued, it is now only from the pits in the neighbourhood of the town of Northwich that rock-salt is procured. At this time there are ten or twelve in number; at all of which the rock is wrought in the lower stratum or bed only. The pits or shafts are for the most part square, and built or formed with timber; but there is one at the distance of about a mile from the town of Northwich, which is of a circular form, and built in brick-work.

In regard to the manner of working the pits or mines, there is nothing of any very great interest or moment to be noticed. By means of boring and blasting the rocky stratum, and the use of wedges with the different mechanical instruments employed in mining, the salt-rock is separated, so as to be raised in large masses, which vary in form and purity. However, before any considerable extension of the workings in the pits, in any particular direction, takes place, care is taken to make sure of a good safe open roofing for the cavity which is to be formed in getting out the rock. In doing this the workmen make use of pointed implements of the common pick kind, working the materials out in an horizontal manner, so as to form an excavation in the rock, and making it in as simple a way as possible, or as the work will admit. In consequence, however, of its being situated a few feet above the purer part of the stratum, the rock which is obtained during this process is commonly of inferior quality, and is, for the most part, made use of in the refineries. The depth of the workings from the excavations or roofings, it is remarked, depends in a great measure upon the nature of the stratum, and the proportion of it occupied by the rock of the purer quality, or, as it is termed, *Prussian rock*. Fifteen or sixteen feet may perhaps, however, be taken, it is thought, as the average depth of the workings in the pits. The cavity thus formed presents a striking appearance; and when illuminated by candles fixed in the rock, the effect, it is asserted, is highly brilliant. In some of the pits or shafts, the excavated roofs are supported and kept up by pillars eight or ten yards square, which are in general arranged with a degree of irregularity: others are worked out in aisles; the choice here however seems to be wholly arbitrary, depending on the men who are employed in the work. Until these few late years, horse labour was wholly employed in raising rock-salt from the pits and shafts about the town of Northwich; but this method has now, in some measure, given way to the best kind of steam-engine, which has been substituted in its stead, in many of them with very great advantage. In others, however, horse labour is still continued to be made use of for this purpose. The men who are employed in working the rock-salt pits, have their pay by the quantity of the material which they raise, having in general somewhat less than half a crown for the ton weight, they finding tools and every thing else necessary for the work.

Roll

ROLL, in the *Manufactories*, fomething wound and folded up in a cylindrical form.

Few ftuffs are made in rolls, except fattins, gauzes, and crapes, which are apt to break, and take plaits not eafy to be got out, if folded otherwife. Ribbands, however, and laces, galloons, and paduas of all kinds, are thus rolled.

The ancients made all their books up in form of rolls, or little columns; and, in Cicero's time, the libraries confifted wholly of thofe rolls. The dearnefs of parchment, and the cheapnefs of papyrus, of which the rolls were made, was the reafon that fcarcely any but paper rolls were ufed.

Voffius fays, they pafted feveral fheets end to end, when filled on one fide, and rolled them up together, beginning with the laft, which they called *umbilicus*, and to which they faftened an ivory or boxen ftick, to fuftain the roll. To the other extremity they pafted a piece of parchment, to cover and preferve it.

Thefe rolls were placed in the libraries perpendicularly to the horizon. The Jews ftill preferve the ancient ufage of rolls for the books they read in the fynagogues.

Rolling-mill

ROLLING-*Mill*, in *Metallurgy*, and particularly in the *Iron Manufacture*, is a mill for reducing masses of iron or other metals into even parallel bars, or flat thin plates: this is effected by passing the metal, whilst red-hot, between two cylindrical rollers of iron or steel, which are put in motion by the power of the mill; and being so mounted in a strong metal frame, that they cannot recede from each other, they compress the metal which is passed between them, and reduce it to a thickness equal to the space between their surfaces.

It requires a most enormous power to put in motion the rollers which are employed for laminating iron in the large way; and for this reason, the greatest number of rolling-mills are situated upon the banks of rivers which have the advantage of a sufficient fall to turn the machinery. Of late years, the improvements of steam-engines have been carried to such a high perfection, as to put them on a par with water, for most purposes, and particularly for rolling-mills, as the waste heat of the furnaces used for heating the metal may be employed, in part, to raise steam for the engines which turn the rollers.

Rolling-mills were not very generally used in the iron manufacture till within these sixty years. The old mills which were first used are extremely simple; two separate water-wheels are placed on the opposite sides of the mill, with their axles in the same direction, but at different heights, so that one wheel can be connected with the upper, and the other with the lower roller: it therefore requires the two wheels to have the water delivered at opposite sides, to make them revolve in different directions, in order that the upper surface of the lower roller, and the under surface of the upper roller, may move in the same direction, and pass the iron between them. The construction of the rollers generally used in such mills is shewn at *figs.* 3, 5, and 6, of *Plate* V. *Iron Manufacture*, except that the two rollers, F and G, are there shewn with equal pinions, *d* and *e*, fixed upon the ends of their pivots, to compel the two to revolve equally together; whereas, in the mills with two separate wheels, no provision is made to ensure the equal motion of the two. The gudgeons, or necks, of the lower roller, G, are supported in brasses, fitted into strong carriages of iron E, E, which have holes through their ends, to receive four strong iron bolts, A A, B B; these stand perpendicular, and form the frame, to retain the rollers at the proper distance, being fitted through the carriages E with heads below, so that they cannot draw out. The upper ends of the bolts are cut with screws, upon which nuts, *a*, *a*, are fitted; and these being turned round by iron handles or wrenches, screw down the pieces D, D, and advance the rollers nearer together; or, by a contrary motion, increase the distance between them: *i* (*fig.* 6) is a strong iron bar, extended from one bolt, A, to the other, B, and fixed fast; it supports an iron plate, forming a kind of table before the rollers, to guide the iron through them. The rollers have square heads upon the ends of their gudgeons; and upon these squares, large cast-iron sockets or boxes, as L, are fitted, and these, at the other ends, are fitted upon similar squares on the ends of the water-wheel axis. A little play or looseness is admitted in all these squares, because the upper roller is set at different heights, according to the thickness of the work which is to be rolled between them: this play is required to allow the rollers to move freely, when they are not exactly in the line of the water-wheel axis: it is to accommodate this circumstance that the principal care is required in constructing a rolling-mill. Our readers will gain a good idea of the best proportions of a mill, with two independent water-wheels, from the following directions for building one in Northumberland, which were given by Mr. Smeaton near 40 years ago. The two water-wheels are to be under-shot, and of different sizes, *viz.* 15 ft. 4 in. and 14 ft. 8 in., the mean diameter being 15 ft. The breadths in their float-boards are to be three feet each, the small wheel being laid lower than the other by seven inches: this, with the differences of their diameters, will make the centre of the large wheel 11 inches higher than the other. The different heights of the crowns of the falls or breasts, down which the water descends to act upon the wheels, and the positions of the water-shuttles, are to be so adjusted, that the gates or shuttles being equally drawn up by their starts, the wheels will, as near as possible, revolve in equal times, and with equal power. The rings of the water-wheels are to be made of cast iron, that their weight may act as flies: the ring of the lesser wheel is to be made six inches in thickness by six inches deep, while that of the larger is to be only five by six. The greater quantity of matter in the lesser wheel, therefore, will give it nearly the same momentum as the larger wheel.

The rings of the water-wheels are each to be formed by eight pieces or fellies, the exterior circle of the greater wheel being thirteen feet diameter, and that of the less twelve feet four inches: the length of the fellies is to be about half an inch shorter than their true length, in order to admit an oak wedge of one inch thick to be introduced into every joint after the rings are screwed together by the joint-plates of wrought iron, which unite the fellies. These plates are to lay upon the plain surface of the felly, and not to be let in as the common wooden rings of water-wheels, in order that the oak wedges may completely fill the joints at the ends of the fellies. The wheels are to have wooden arms, and it must be observed, that the mortises through each of the iron fellies, for receiving the ends of the arms of the wheels, are to be about two inches and a half in width, and that they are to be a little dove-tailed, in their length only, so that the mortises being longer on the outside of the ring, and the wood of the arm being spread into them with wedges, will produce firm ties to the centre; but as a farther security, pins are to be put in after the wedging is completed. The mortises in the rings for the starts, which support the float-boards, are to be four inches by two, without dove-tailing, or rather they should be larger outside than inside. The breast or float-boards will fix by nails into the joints and arms, where they fall; but that the breast-boards for the intermediate floats may also have a fastening, holes of about one inch diameter, and about four inches deep, must be cast in the ring, at the places for every other float; these holes, being filled up with pieces of oak, will afford places to drive the nails for securing the boards. The axles of the water-wheel are to be of cast-iron, with flaunches to screw the arms of the wheel against. The total length of each axis is to be seven feet one inch, and the diameter throughout the axis is to be a circle of nine inches. The manner of fixing the arms upon flaunches is to be found in *Plate* XXXIV. *Mechanics*, in our article MILL.

The braffes upon which the necks of the water-wheel axles are fupported, are intended to be let into caft-iron ftocks, which are again fupported upon wooden bed-planks, and thofe upon the cap-ftones of the walls, which (under thefe at leaft) are fuppofed to reach all acrofs the thicknefs of the walls, thofe necks being firft truly and fmoothly turned; at each end, beyond the neck, is formed an aftragal or moulding, to keep the wheel in its place from moving endways. The ends of the axis are terminated by an indented head, fhaped fomewhat like a fquare citadel in fortification, and an iron box is fitted upon this to communicate the motion to the rollers, the furface lines of the indented head being formed a little rounding, that the box may not only be certain of taking its bearing in the middle, but likewife be capable of complying with the motion of the rollers: and in order to give ftill more liberty, the end of the box which is fartheft from the water-wheel, is formed into a fquare of eight inches, which is again furrounded by another box, whofe external furface is round. This box is formed at the end of a round fpindle or axis three feet long, and terminated at the other end with a fquare of eight inches, which enters one end of a fquare box, and at its other end receives the fquare of the roller, fuppofed to be of fix inches, but may be of any other fize which is thought neceffary. It is to be noted, that all the fquares are to be made larger than thofe of the rollers, in order that they may wear longer; and all the infertions are to be lefs than thofe at the end of the water-wheel axles, that the axis may not be rendered ufelefs by the wear or failure of the citadel heads which are introduced, as they are expected to laft many years; and if any thing fhould happen to them, the axes are made alike on both fides of the water-wheels, that they may change ends; therefore, there is nothing of confequence likely to fail by wear or breakage, except the fmaller intermediate work between the axis and the rolls, which is eafily replaced. Holes are to be made through the boxes and joint parts for iron bolts to pafs through rather loofely, fo as to prevent the boxes and fquares feparating, but not to confine the joints from yielding to the motion of the rolls. The water-wheels are fuppofed to be clofely adapted to their conduits, and their axes to remain immoveable as to height, at the difference of eleven inches in level, while the rolls are fuppofed to vary in their diameter from twelve inches to nine. This will be allowed for, by the diftance that the fquares upon the rolls are from the end of the axis; for though the houfe is fuppofed no more than ten feet wide between the walls, the diftance between the middle of the citadel heads at the end of the water-wheel axis, and the middle of the fquares of the rolls refpectively, is upwards of four feet; and in that length no lefs than four joints are introduced, every one of which complying a little, a fmall difference in the height of the roll will produce no fenfible difference in the communication of the motion from that of a right line; all the joints being kept oiled or greafed, which will be not lefs proper on that account than to keep the parts from wearing. In order to preferve the directions as near as poffible to a right line, Mr. Smeaton propofes that the lower roll fhall be placed originally half an inch below the centre of the axis which turns it: fuppofe the rolls were firft made of twelve inches diameter, while the difference of the height of the axis is only eleven, the upper roll will be juft half an inch too high, fo that the compliance in each will be equal, and no more than half an inch in four feet length. Thus it appears, that when the rolls are reduced by wearing from twelve inches to eleven each, then the upper roll as well as the lower will be half an inch too low for its axis; ftill neither will need to comply or vacillate more than half an inch. The roll being now of a juft diameter to anfwer the different heights of the axis, let the lower roll be raifed to its juft height, and then both the rolls will work true till they are further reduced; but when they become reduced to ten inches and a half diameter, the upper roll will become half an inch too low; then raife the under roll half an inch above the line, and the upper roll will then be truly in the line; fo that when the upper roll is come down to be half an inch below the line, the rolls will be reduced to ten inches; then raifing the under roll a quarter of an inch more, it will be three quarters above the line, and the upper roll will be a quarter of an inch under the line; and when it comes down to three quarters below the line, the rolls will be reduced to nine inches and a half; therefore, laftly, raife the under roll another quarter, fo as to be an inch above the line, and the upper roll will be reduced to half an inch below it, fo that when it is come down to an inch below it, the rolls will be reduced to nine inches. In this way the departure of the rolls from a right line will never become more than half an inch, while they are reducing from twelve to ten inches; nor more than three quarters, while they are reducing from ten to nine and a half inches; at the worft they will be no more than an inch, while they are reducing from nine and a half to nine inches. The greateft inequality is purpofely made at this place, both becaufe the purchafe of the wheels is then greateft and moft able to overcome an addition of friction, and becaufe the time that they will continue in this ftate is the leaft. If the axles are placed at ten and a half inches diftance inftead of eleven, the vacillation each way will never exceed three quarters of an inch; nor more than one inch to reduce the rolls to eight and a half diameter.

The raifing of the under roll is not to be done by raifing the whole of the bed of the roller-frame; this is to be fet originally half an inch lower than the true line; and when the lower roll requires raifing, it is to be effected by putting iron plates under the carriages of the lower roll gudgeons, fo that they will ftand as much higher than before, and not to make the feveral rifes by additional plates, but to have plates of the different gages, fo that each will lay in one folid piece.

Mills, on this conftruction, are ftill ufed in many iron-works for rolling coarfe iron bars, but are unfit for any better purpofe, from the difficulty of adjufting the two water-wheels to an equal velocity; and if one roller moves quicker than the other, the metal becomes more extended that fide than upon the other, and is thus rendered ivex. Another defect is, the want of proper fly-wheels to regulate the mill; for the caft-iron rims to the water-wheels by no means anfwers the purpofe of fly-wheels, unlefs they are made to revolve fo quickly that the water lofes much of its effect upon the floats. Fly-wheels are, perhaps, more ufeful for rolling than in any other kind of mills, becaufe the refiftance to be overcome is fo variable; being at one moment very great for a large piece of iron, then fmaller whilft it is paffed through a fecond time, becaufe the iron is to be lefs reduced: and in the interval of returning the iron, to put it through again, there is no other refiftance than that of the friction of the machinery. Again, when the iron has been paffed through feveral times, the refiftance is greateft of all, becaufe the metal has become harder, both by the compreffion it has undergone, and from being gradually cooled; alfo, the metal, being thinner, will not yield fo readily to the preffure, as when in a larger mafs. By the proper addition of a heavy fly-wheel, great advantages, in point of power, are gained, as it tends to

equalize all these irregularities; and in every interval, when the resistance is removed, the water-wheel gives a rapid motion to the fly, the force of which will be returned when the work is applied: in such a mill, if the workmen have an extraordinary large piece of metal to roll, they suffer the mill to work for a few seconds without any resistance, then putting in the iron, it is carried through at once by the momentum of the fly, though requiring a power far beyond the ordinary force of the water-wheel. The most approved method of applying a fly-wheel to a rolling-mill, is to have a large cog-wheel upon the axis of the water-wheel, to give motion to a pinion, upon the axis of which a heavy iron fly-wheel is fixed: the wheel and pinion are of such a size as to make the fly revolve about three times to one of the water-wheel: at the opposite side of the great cog-wheel another pinion, of about half its size, is placed, and to the extremity of its axis produced, the rollers are connected, the two rollers being made to turn together by means of pinions upon the ends of their gudgeons, in the manner shewn at *d e*, *fig.* 6. *Plate* V. If more than one pair of rollers is to be worked, a cog-wheel is fixed upon the axis which turns the rollers, and works another equal wheel upon the axis of the second pair, placed parallel to the former; in this case the lengths of the two axes must be different, so that the lines in which the bars will come through the different rollers, will not interfere with each other, but leave sufficient room between for the men to work. In most common mills, rollers, such as are represented at *figs.* 3, 5, 6, of *Plate* V. are employed; but to these there are some objections; first, the four nuts *a*, *a*, cannot all be turned at once with such precision as to bring the upper roller exactly parallel to the other; the means the workmen use for this, is to have a small iron wrench, or handle, fitted upon two of the nuts, *a*, *a*, and these they turn round a small quantity every time the metal has passed through, in the interval whilst it is returned to be put through again. The workman who stands in front to introduce the metal between the rollers, turns the nut on his left-hand side which is nearest to him; whilst his comrade, who receives the metal, and hands it back again to him over the roller, turns the nut on the opposite corner of the frame: by this means, as only two, instead of four, of the nuts are turned, the pieces D are constantly put out of the horizontal position, in which alone they can take a proper bearing; also, in these frames there is no support for the weight of the upper roll; but when there is no metal beneath it, it falls down, and rests upon the other; when the metal is suddenly introduced, it lifts the roll up to its bearing with a jerk, which endangers the breaking of some of the parts, and generally causes the nuts to start a little before they settle themselves to the strain. In the modern mills, the frames for the rollers are made of cast-iron, as shewn at *figs.* 1 and 2. *Plate* V. The cheeks, A, are cast in one piece, and form a bed for the reception of the brass of the lower roller H; a piece, C, is fitted upon the top of the cast-iron cheeks, and is held down by two strong wrought-iron bolts, with nuts, *a*, *b*, to screw it down, and regulate the distance between the two rollers, the gudgeon of the upper roller, G, being confined by a brass let into the piece C, but to bear it up from falling: when there is no iron between the two rollers, another brass is placed beneath the gudgeon, G, and suspended by bolts, *d*, *d*, from the piece C; by this means the two rollers are retained always at a proper distance asunder. The two standards A, B, *fig.* 2, at the opposite ends of the rollers, have broad feet at bottom, by means of which they are bolted down to massive ground-sills, which extend all across the mill-house. The rollers E and F are caused to move together equably by means of pinions *a*, *b*, which, that they may work well, are made with accurate teeth, of not more than $1\frac{1}{2}$ or 2 inches pitch, or distance asunder; and, to give the requisite strength, they are made of considerable breadth, as the figure shews. Two large flat iron plates, I and K, are screwed to the two standards, both to strengthen them, and to form a table, upon which the masses to be rolled are laid to be presented to the rollers, and having passed through, are received on that at the opposite side.

The rollers shewn in *figs.* 1 and 2, have a number of grooves in them, which being opposite to each other, leave openings of a determinate figure for the purpose of rolling square bars, with the angles upwards; they do not therefore require to be adjusted in distance, as other plain rollers do, but are always, after the first erection, retained at the same distance; in this case the pinions *a* and *b* serve very well to connect the motions of two rollers together; but when the rollers are required to be adjusted during the working, as in the *Plate Rollers*, *fig.* 6, the pinions must necessarily have very coarse and long cogs, that they may not be so much affected by increasing or diminishing the distance between their centres; in this case they work very indifferently, and frequently break by the awkward manner in which such coarse teeth always meet each other when upon wheels or pinions of small radius, particularly when the proper distance between their centres is not preserved. As a partial remedy for this difficulty, the pinions are, in some mills, made very broad, with fine teeth, and mounted in a separate frame, exactly similar, except in its strength, to that of the rollers; this is placed at a distance of three or four feet from the rollers; then a coupling, or short shaft, being interposed between the squares at the ends of the axis of the pinions, and those of the rollers, they permit the latter to be adjusted without disturbing the pinions; and the length of the shafts will accommodate for the differences between them.

In *Plate* IV. of *Iron Manufacture*, we have given three figures of a very capital rolling-mill in Messrs. Walker's extensive iron-works at Rotherham, in Yorkshire, where they have several mills worked by the same river. The one in question is employed in reducing iron to small rods for nail-making, by first rolling the pieces to flat bars, and then passing them through a pair of slitting rollers, which divides each into several small square rods: it is, therefore, much smaller in its dimensions than the great mills used for rolling thick iron plate; but we have selected it on account of the arrangement of its wheels, which renders it superior to the mills in common use, as it works without the pinions of which we have spoken. A A, in the plan, (*fig.* 1.) is the water-wheel, 17 feet diameter, and five feet six inches broad: it is of the under-shot or rather breast-kind, the water being delivered below the centre, but confined to act upon the wheel by a breast of masonry, curved to correspond with the wheel very exactly. The pivots or gudgeons, *n*, of its axis rest on bearings, supported by the walls N. At one end of the axis a clutch-piece, M, is fixed, to give motion to a second axis *k*, which, being in the same line as that of the water-wheel, may be considered as a continuation thereof. It is carried under the floor of the mill. It has two large cog-wheels, one marked *b*, and another of the same dimensions at the opposite end, which is only seen in *fig.* 2, as it is concealed in *fig.* 1, beneath the wheel *f*, which it turns. The first of these wheels, *b*, gives motion to two wheels, *a* and *c*, which are on the axes I and H, and give motion to the lower of each of the two pair of rollers, situated in the frames at E F and C D. This wheel-work is shewn in

fig. 3. The wheel at the other end of the ſhaft, *k*, (ſee *fig.* 2.) turns the wheel *f*, ſituated directly above it; and this gives motion to two wheels, *e* and *g*, of the ſame dimenſions as *a* and *c*. Their axles, L and K, are connected with the upper of each pair of the rollers. By the introduction of the wheel *f*, the ſmall wheels, *e* and *g*, are made to revolve in a contrary direction to the wheels *a* and *c*; and, at the ſame time, the centres of the former are raiſed a ſufficient height above the latter, to allow for the difference in height of the centres of the upper and lower rollers of each pair. The coupling-boxes, L K and *p p*, which unite the axles of the wheels to their reſpective rollers, have ſufficient play in the joints to allow for that ſmall deviation which takes place in ſeparating the rollers, to adjuſt them to different thickneſſes of the metal they are intended to roll; though theſe ſhanks ſhould be repreſented longer than the limits of our plate have allowed, the ſpace between the frames for the wheels being in reality eight feet, inſtead of five feet nine inches, as given in the drawing.

By this arrangement of the wheels of the mill, the contrary motions of the two rollers are communicated from the ſame water-wheel, without the intervention of ſmall pinions, which, in works requiring ſuch heavy ſtrains as that of rolling iron, always work with difficulty and enormous friction; ſo that they break and wear out conſtantly, making great interruptions to the work. In the preſent inſtance, the wheels are all of conſiderable ſize, and, therefore, tranſmit the power more equably, at the ſame time that they give the two rollers preciſely the ſame velocity, which is a circumſtance of ſome importance in making good rolling for plates or bars, which will be irregular, if one roller turns faſter than the other, in conſequence of one ſide of the metal being more expanded. The framing of the mill (*Plate* IV.) is very clearly expreſſed by the drawing. The axles H and I, of the wheels *a* and *c*, are ſupported in bearings, ſcrewed down to iron frames, which are ſecurely fixed to the ſolid maſonry. On the other ſide, the iron frame, O O, is erected to ſupport the axles of the wheel L K, and alſo that of the wheel *f*, as ſhewn in *fig.* 2. The main axis *k*, and the wheels upon it, are carried under ground, and ſupported on the walls, as ſhewn by the plan. The roller-frames, C D and E F, (*fig.* 1.) are fixed down upon ſtrong beams, extended acroſs from the frame, O, to the frame on the oppoſite ſide. The poſition of one of theſe beams is ſhewn by dotted lines on the right-hand ſide, in *fig.* 1. The rollers, C, D, are exactly the ſame as ſhewn in *Plate* V. *figs.* 3, 5, and 6, except that the pinions, *d* and *e*, are omitted, being unneceſſary, from the arrangement of the wheels, which we have deſcribed. The other rollers at E F are made on a very different conſtruction, and are called ſlitters, becauſe they ſlit or cut up a bar of iron into ſeveral ſmall ſquare bars, of a ſize proper for nail-makers, or to form hoops for barrels. Theſe ſlitters conſiſt of two ſtrong axles, mounted in a ſimilar frame to the other rollers; but inſtead of carrying plain cylindrical rollers, they have rollers compoſed of ſteel rims or edges, of the ſame breadth as the rods they are to ſlit, and leaving between them deep grooves. The two ſlitters, or cutters, are ſo placed in their frame, that the rims of one roller will enter into the grooves between the rims of the other. This will be underſtood by an examination of *fig.* 4. *Plate* V.; though the rollers there ſhewn are for a totally different purpoſe, ſtill the manner in which the rings of one roller enter the grooves of the other is the ſame as the ſlitters: but the proportion of breadth is different, the ſlitters being made with grooves of half an inch, three quarters, or one inch wide, and many intermediate ſizes, correſponding to the rods to be cut; and they are not made from a ſolid roller, but are formed of ſeparate circular plates of ſteel of the juſt thickneſs, fitted ſide by ſide upon the axis, with circular iron plates of equal thickneſs between them, which form the ſpaces; and being of a leſs diameter than the ſteel plates, or cutters, they leave deep grooves between the edges. A number of crooked guide-bars are extended acroſs the frame, and paſs through the grooves, between the cutters; but lying at the very bottom of the grooves, and not being very thick, they do not fill up the grooves, the circles of the cutters projecting through theſe bars, which appear like a grate, and one is applied to each roller. Thoſe which are called the guides of the ſlitters are intended to prevent the iron adhering in the grooves between the rims, or cutters, when preſſed down into them; for the action of the ſlitters is to divide the iron which is paſſed through them into ſeparate pieces, by the rim of one roller (for inſtance, the lower) forcing one piece of the bar down into the groove of the lower roller, whilſt the adjacent part is forced up, by the rim of the lower roller, into the groove of the upper: the bar is thus divided into as many rods as there are grooves in the width which it covers. The angle at which the circles of the cutters interſect each other, is that in which the edges of a pair of ſhears are found the moſt favourable for cutting; and the ſlitters cut upon the ſame principle, but with ſeveral edges at the ſame time.

A rolling-mill generally contains a pair of ſhears, of a ſufficient ſtrength to clip off the ends of the largeſt iron bars, to reduce them to lengths or pieces of a ſufficient ſize for laminating into thin plates. Theſe are made different from other kinds of ſhears, in the circumſtance that the cutting parts, or edges, are ſituated between the centre pin or joint, and the part or handle where the power is applied: the latter is of great ſtrength, and made exceeding ſtrong in iron. The ſhears are fixed in a vertical poſition, the upper blade being firmly fixed by the framing, and the lower one, which is the long lever, is lifted up by the mill when the cut is to be made; therefore it deſcends when the ſhears are to open, and its own weight is ſufficient for that purpoſe. The frame conſiſts of a very large and thick iron plate, which is ſecurely bolted down to the foundations: at one end is an upright, which has a groove through it, to receive the moving blade, and guide it; alſo the end of the handle of the ſtationary or upper blade is ſupported by the upper end of this upright. The joint-pin of the two blades is ſupported in a ſtrong ſocket, or iron frame, alſo erected from the ſame large plate, which carries the upright guide at its other end. The two blades, therefore, lie ſide by ſide, and having cutters, or blades, of ſteel, let into the adjacent ſides of the iron levers or blades, the edges of theſe paſs by each other when the cut is made, and will thus cut any thing which is interpoſed between them, in the ſame manner as ſhears or ſciſſars; and in this circumſtance is their only reſemblance to thoſe inſtruments. The lower or moving blade, which is a long lever, reſts at the extremity, upon the periphery of an elliptical wheel, or camm, (*figs.* 1, and 3.) fixed upon the axis, I, of the rollers, (or, in other caſes, upon the ſhaft of the water-wheel,) in an excentric manner, ſo that, in turning round, it will lift up the lever, and cloſe the ſhears; but when its oppoſite or ſhorteſt radius comes beneath the lever, it is ſuffered to deſcend, and open the blades. At this moment the workman introduces the end of the iron-bar between the blades, puſhing the end of it up to a ſtop, which regulates the length to be cut off; then as the camm turns, it cloſes the blades, and cuts at once through the bar, although ſome of the largeſt are as much as three inches broad, and an inch thick.

Rollers are usually made of cast-iron, and are very exactly turned on their surfaces, and also their necks, that they may turn truly when put in their places. The most common way of turning them is, first to mount the roller in a strong turning lathe, by holes or centre points made in its ends; then to turn the two necks truly cylindrical; and afterwards putting the roller in its proper place in the roller-frame, and placing brasses over the necks, they are held down by blocks, fitted under the pieces which retain the gudgeons of the upper roller: in this situation it is put in motion by the mill, and a bar of iron being fixed up for a rest, the surface of the roll is turned true, in the same manner as if it was in a lathe, and will be certain to be exact, being formed from the same necks on which it is afterwards to work. In casting a roller, the mould should always be placed at a considerable depth beneath the orifice where the metal is poured in, so that the pressure of a column of the fluid metal may be obtained to consolidate the casting, and render it free from those air-holes, or porous places, which will sometimes occur in metals cast without the pressure of a column. The long piece of metal which filled the aperture through which the metal ran, is left adhering to the roller, and is cut off afterwards. This is the same mode of casting that is practised for *cannon* (see that article). Case-hardened rollers must be used when it is required to have a very fair surface; *viz.* for such purposes as rolling iron to make thin plates for tinning; also the large rollers for gold or silver, such as are now used in the Royal Mint; rollers for making tin-foil, steel-plate for saws, and for many other purposes. These rollers are not hardened by a subsequent process, as in case-hardening wrought iron, but are cast in that state. This is effected by employing iron moulds: a cast-iron cylinder of three inches thick, and its diameter equal to that of the roller, is bored out with great accuracy, and fitted with ends proper to form moulds for the necks required at each end of the roller; this is buried in the sand of the foundry, and when the metal is run into it, the rapid transmission of the heat through the iron mould causes the metal which is in contact with it to cool sooner than the other parts of the mass, and renders the surface of the roller very hard. In turning a roller of this kind, the centres must be chosen so that the circumference turns as true as it will admit, and then a very small quantity being taken off, will render it perfect: this care should be taken for two reasons; first, that less will be required to be removed to make it true, which is a difficult operation, as only the best steel tools will cut it; also, that if the metal is unequally reduced, or more on one side than the other, the hardest part will there be cut away, and the roller will have a hard and a soft side, and soon wear out of the circular figure, and require a second turning. The less metal there is turned off a case-hardened roller the better it will be, because the hard part is only a case of slight thickness, and most hard at the surface.

The operation of the rolling-mill is so simple, as scarcely to require any description: the metal is heated in reverberating furnaces when it is in large masses, and for smaller pieces a kind of oven is used, in which the cokes are laid on the bottom or floor of the oven without any grate-bars, and therefore the draft of air being less rapid, it gives a slight, but very regular heat, which rises to a bright red, but no farther, and therefore it does not waste the iron by burning it to scales, as a greater heat and current of air will do. This oven is proper for heating plates, hoops, or small bars, to be rolled a second and third time: but for rolling large masses, a strong welding heat is requisite, that the metal may be consolidated, and all flaws or cracks securely closed. The reverberating furnace is used for this purpose; it is made the same as an air-furnace for melting large quantities of iron, except that the floor is horizontal; indeed it is as near as possible similar to the balling furnace. (See *Plate* II. *Iron Manufacture.*) The furnaces are placed as near as convenient to the rollers.

The iron, being heated in the furnace to the proper degree for the purpose which is intended, is taken out by a pair of pincers, the mill put in motion by drawing the shuttle, and the iron is presented to the rollers, which are previously adjusted to the thickness of the piece which is to be passed. If this is not attended to, and the workmen attempt to reduce the iron too much at one time, there is danger of breaking some of the machinery, or of stopping the mill whilst the iron is only half passed through: this is a disagreeable accident, as it will require four or five men, with an enormous wrench applied to the nuts of the roller, to turn them back sufficiently to relieve the rollers, so forcibly are the screws pressed whilst the iron is passing through: this is indeed evinced by the circumstance of solid cast-iron rollers, of ten inches in diameter, being sometimes broken in the middle; and the necks of eight and nine inches are frequently snapped. When the iron is placed on the shelf or table before them, their motion will draw it through, and as they cannot recede from each other, because of the nuts of the bolts, the metal is reduced to the exact thickness of the space between them, increasing in length, but not at all in breadth: the iron is caught by another workman behind the rollers, and returned over the top roller to the first man, who puts it through again, first giving the handles of the nuts a small turn, to bring the rolls nearer together. In this manner it is repeatedly rolled, till it is reduced to any required length and thickness, but the breadth is not at all increased by rolling; and if it is required to increase the breadth, it is done by putting the iron obliquely through the rollers; or if a great increase is wanted, the iron is put through breadthwise two or three times, till it is extended to the length of a gauge which the workman has marked upon the table in front.

Rolling of black Plate, such as is used for making the boilers of steam-engines, tanks, or other large vessels, in wrought iron. Such plates, when large, and of considerable thickness, are rolled from the blooms, or half blooms, which are made under the forge-hammer. These blooms, which are also called slabs, are nearly the length of the intended plate; their breadth about one-half or one-third as much as their length, and of a thickness to contain as much metal as will make two, three, or four plates. These pieces, when heated to a white heat, are presented breadthwise to the rollers, and passed through several times at the same heat, until what was the breadth of the bloom, being extended two or three times as great, becomes equal to its length. The thick square plate, thus formed, is now cut up by the shears across into two or three pieces, of about the same size as the first, but in a direction which will make what was the length of the first piece to be the breadth of the second. These pieces, being heated and rolled again, become extended to the size of the required plates: the reason of thus dividing the operation is, that the rolling only extends the metal in the direction in which it moves, and not at all in breadth: by this means, the particles of iron being drawn by the sides of one another, acquire something of a fibrous texture, or an approach thereto, which is desirable in bars, rods, and hoops, but not at all in plate, as it should be equally strong in either direction; therefore, by rolling it first one way, and then the other, the grain, as far as it is produced at all, is in both directions. There is no doubt that better plate would

be made, if the flabs or original pieces were cut to the proper proportions of length and breadth, and of a thicknefs to form only one piece; then rolling it alternately length and breadth ways every time it is paffed between the rolls, and continuing this till the plate is finifhed, at one heat; a better grain or texture will be thus acquired, becaufe in the former method it will be weaker one way, having fomething of a grain in the direction of the laft rolling.

Rolling iron Plates which are to be Tinned.—Thefe are made from the beft Englifh iron, and fome of the very thinneft from foreign iron; the bars are drawn out, by the forge hammer, to five inches broad, and half an inch thick, and are cut into lengths of eleven inches by the fhears; thefe are heated in an oven, and paffed breadthways through cafe-hardened rolls: this is repeated till they are extended to twice the length of the intended plates: the pieces are then folded, and fet on edge in the furnace till properly heated, when they are rolled double, the fold being put in firft; they are thus extended to twice the length of the folded plate. Now two men, with ftrong tongs, tear the two leaves afunder at the fold, and fold each again feparately, putting one into the other, like two fheets of paper; in this ftate they are heated, and rolled four thickneffes together, the next time eight, and fo on, till the plate is reduced to the required thicknefs: in the very thinneft plate, fuch as is ufed for tagging laces, fixteen leaves are rolled together. In folding the plates, care is taken every time to put a new furface of metal outfide, otherwife, thofe which were conftantly reduced by the preffure of the adjacent leaves, would, at length, become grained on the furface; but by continually gaining new furfaces, which are fmoothed by the immediate contact of the rollers, thofe which are laid againft them are alfo rendered fmooth. A fmall quantity of oil is fprinkled between the leaves, when they are firft put in, and inftantly fpreading over the whole furface, prevents any adhefion; the plates are dreffed fquare by the fhears every time before they are folded, to remove thofe parts which, by projecting over the edges of the other leaves, are not fo much reduced.

After being finifhed, dreffed fquare, and the furface fcowered, the plates are rolled, fingly, between a pair of polifhed cafe-hardened rolls, without being heated; they are therefore extended but little in fize, though rendered much harder, and more ftiff. *Tin-foil* is rolled much in the fame manner as the plates for tinning, but of courfe without heating.

Rolling, or Shingling Iron by Rollers.—This is a modern invention in the manufacturing of bar-iron, the rollers being fubftituted for the forge hammer to work the metal, in the procefs of rendering it malleable. This method is only ufed in conjunction with the *puddling* procefs, that is, puddling, or converting, caft-iron into a malleable ftate, by decarbonating it in a reverberating furnace; in this procefs the metal becomes divided into grains the fize of muftard feeds, with a very flight cohefion, and full of interftices between the grains; it therefore requires to be ftamped, or hammered, at a welding heat, into a folid mafs; but rolling will alfo anfwer the purpofe.

This was firft difcovered by the late Mr. Wilkinfon, who had, in his extenfive works at Brofely, in Shropfhire, a pair of enormous rollers, moved by the beam of the fteam-engine, not with a rotatory, but with a reciprocating motion; they were five feet diameter, near ten feet long, and weighed almoft five tons each, although caft hollow, like garden rollers; fectors were fixed on the ends of the gudgeons, to turn each other, as they did not make above one-third of a revolution, and then moved back again. The circumference of the rolls were grooved with grooves, gradually diminifhing from one end to the other, in the fame manner as the rollers fhewn in *Plate* V. *fig.* 1. The mafs of iron to be rolled was collected into a ball in the furnace, which was taken out, and paffed through the greateft of the grooves. When it came through, a workman at the oppofite fide removed the ball to the next fmalleft groove, and by the returning motion of the rollers, it was carried back again to the front: the front workman then returned it in another groove, and fo on, paffing fucceffively through the different grooves, until, by gradual confolidation, it was reduced to an imperfect bar of malleable iron. A number of thefe, being cut into lengths, were made up into faggots, or piles, and by a pair of rotatory rollers finifhed into bars. Mr. Wilkinfon had a patent for this machine, but it was afterwards found that other rollers would effect the purpofe better. In *fig.* 1. of *Plate* V. is a view of a pair taken from Mr. Samuel Smith's works, at Sheffield, Yorkfhire, a gentleman who, we believe, was the firft who brought them into ufe; the two grooves *e* and *f* are very coarfe, and have teeth, that they may, more certainly, draw in the balls. The two next grooves are plain but concave, and the remainder are angular, to form fquare bars when the ball becomes confolidated. The ufe of thefe rollers is very fimilar to thofe we have juft defcribed, the ball of metal being taken from the furnace, and prefented to the rolls. As foon as the metal comes through the rollers, a workman behind lifts it over the upper roll to the firft workman, who puts it between them again: in this manner the metal is rolled ten or twelve times, being put through a fmaller groove of the rollers at each time, fo as to comprefs it in a greater degree every time, till at laft it is reduced to a tolerable fquare bar; but the laft groove E, *fig.* 2, has teeth in different parts of the groove, and at fuch diftances from each other, that they will indent fo deeply upon the angles of the bars, at every eight or ten inches of their length, as to render it eafy to break them into fhort pieces when they come through. The pieces, thus formed, are piled four together, and put into a ball furnace, and, when heated, they are rolled into bars, by rollers fhewn at *fig.* 4, which, at the firft five grooves, *e*, *f*, are fimilar to the former, but the fucceeding grooves, *k*, *k*, are made to receive the rings of the oppofite roll, leaving fmall rectangular fpaces, as is fhewn by the light parts, *fig.* 4, through which the iron, being paffed, is reduced to a parallel fmooth bar. The fucceffive grooves through which it is paffed are each made narrower than the preceding, fo as to reduce the bars to the width and thicknefs intended. in which ftate they are fent to market, or if required for the nail rods, or hoops, are cut up by the flitters. The rollers are thought to inclofe the impurities in the iron, rather than expel them; but as rollers require much lefs power to give them motion than the hammer, it becomes worth the confideration of manufacturers to improve their conftruction, and render them equal in effect to the hammer. At prefent the rolled iron is not always fo good in quality as the hammered, though this circumftance fhould not deter manufacturers from ufing it, as it is fcarcely poffible that a newly invented procefs fhould be at firft brought to equal perfection with another which has exercifed the ingenuity of manufacturers for ages paft. But in the courfe of practice many improvements may arife, which will remain undifcovered if the procefs, in its prefent ftate, is neglected; even in this ftate the puddled iron, made with rollers, is by no means to be defpifed, when its price and quality are compared; it is for iron requiring the fibrous texture that this procefs is beft adapted.

Rolling and flitting iron for nail rods or fmall hoops. The

iron which is subjected to this process is brought to the mill, *Plate* IV. before described, from the forge hammer, in bars of a size proportionate to the nail rod it is intended to make; these are cut into lengths by the shears, and heated in the furnace, then rolled repeatedly through the rollers, C, D, which are reduced every time it passes, until the bar becomes of the thickness for the square of the intended rod, half an inch for instance, and two, or two and a half, inches wide: it is, in this state, presented to the slitters E, F, and one end being introduced between the guide-bars of the slitters, is drawn in between them by the motion, and, by this means the ring of one roller presses a corresponding breadth of the hot metal into the space between the rings of the other roller; this being performed by both rollers, completely divides the bar into several rods of the same breadth with the rings of the rollers. A small leaden pipe is fixed over the cutters, and being perforated with holes, constantly lets fall a supply of cold water on the rollers, to prevent their becoming hot, and thus losing their hardness, which alone preserves their circular figure under the intense pressure they have to sustain in dividing the iron. The guide-bars are intended to force the iron rods, when cut, out of the grooves between the rings of the collar, which they would not otherwise quit, after being so forcibly pressed into them by the rings of the opposite roller. For making small hoops, the rods, as soon as they are formed, are put through the plain rolls again, and flattened into a hoop.

Rolling of Iron Hoops.—In the country these are made from iron bars, which are reduced in rollers, similar to *fig.* 4, to a size proper to produce the hoops required; these are cut into lengths, heated, and passed through the slitters, which divide them into three or four rods, which are immediately presented to the case-hardened rolls, and flattened out into a proper hoop. The mill shewn in *Plate* IV. is equally adapted for this work as for nail-rod; but for hoops, the addition of a proper fly-wheel would be an improvement, as the work is so much heavier.

In London, where a vast quantity of old hoops is to be procured, they are re-manufactured, and make the very best sort. The victualling-board alone consume many hundred tons annually for the service of the navy: the old hoops are made up into faggots, and shingled, or welded into bloom at one heat, by a forge-hammer, or in small works by rollers like *Plate* V. *fig.* 1. The blooms, being again heated, are rolled out into bars by the bar rollers, *fig.* 4, and these are cut into two or three lengths, according to the sizes of the intended hoops; these pieces are heated a third time, slit into rods as above described, and then formed into hoops by the case-hardened rolls. By successive improvements it has been found, that two heats are sufficient, the first for shingling and forming the bars, and the second for slitting and flattening the hoops; but in either method the grand object is by faggoting and rolling, always in the direction of the length, to gain a fibrous texture to the iron.

Old hoops have been lately made up into new at one operation; by employing a greater power and velocity, and making up a smaller quantity at once, it may be effected at a single heat, instead of two or three. For this purpose the old hoops are cut into short lengths and faggoted in piles, the rivets being first cut out and the pieces straightened, that the piles may be more close and compact: these piles are heated in the usual kind of furnace to a good welding heat, and are rolled between the shingling rollers, being passed through two or three grooves till they are properly reduced to go through the flat-grooved bar rollers: after rolling through the three grooves thereof, they are put through the flat parts, and a guide is used to direct them straight forwards, without care or attention from the workman. The bar is then carried to the cutters, and slit into two or more rods, which are immediately and successively passed between a pair of plain, case-hardened rolls, to finish the hoops.

Vat-hoops, or others above two inches in width, do not require to be slit, but are at once carried from the bar rollers to the plain rollers, which finish them. The piles for shingling must not be made too large, or the hoops will not retain sufficient heat to be sound; about 42lbs. will be a proper quantity. The mill for this manufacture must of course have great power, and the rollers should move with a sufficient velocity to enable the iron to be got through the whole process whilst sufficiently hot. The bar and shingling rollers should be placed close together in a line, and must make about 90 revolutions *per* minute; the case-hardened rollers should make 140 *per* minute, and should be placed in such relative situations as will be most convenient to convey the iron in the quickest manner from one pair to the next. A patent has been taken out by some, who pretend to the invention of the above method; but they cannot prevent other manufacturers using it, as it is no new invention, consisting only in taking more care, and using rollers with a greater velocity.

The rolling-mill is not confined to the laminating of iron, but is likewise employed very extensively for reducing brass, copper, tin, lead, as well as gold and silver, into plates and bars. The latter metals are scarcely ever reduced by any other means than rolling; as this method makes no waste, is the most expeditious, and produces better work than hammering, or any other method, particularly when an equality of thickness and an even surface are desired; such, for example, as gold or silver, which is always to receive a polish; in these cases the rollers are made of steel hardened and polished on the surface with the most scrupulous nicety, that they may produce a perfect surface on the matters which have been passed through them.

Rope

ROPE, an aſſemblage of ſeveral twiſts or ſtrings of hemp, twiſted together by means of a wheel; of various uſes, as in binding, ſtaying, drawing, ſuſpending, &c.; or, all cordage, in general, above one inch in circumference, moſtly made of hemp ſpun into yarns or threads of a certain length; and a number of theſe yarns or threads, according to the ſize of the rope, are twiſted together, and called a ſtrand. Three of theſe ſtrands twiſted or laid together, is called a hawſer-laid rope, and nine of them a cable-laid rope. See ROPE-*Making*.

When the rope is made very thick, it is called a *cable*; and when very fmall, a *cord*.

Though it be difficult to give a certain account of the forces required to bend ropes of different diameters, in making them go round bodies of different bigneffes, yet to make no allowance for the lofs of motion fuftained thereby, would be as prejudicial to the practice of mechanics, as it would be to overlook the friction of the parts of engines. The difficulty of afcertaining this force arifes from the different materials of which they are made, their different ftiffnefs according as they are more or lefs twifted; and fometimes from the temperature of the air, as to moifture and drynefs.

Dr. Defaguliers has computed the forces required to bend ropes of different diameters, ftretched by different weights, round rollers of different bigneffes. The refult of his experiment is expreffed in the following table.

Diameters of the ropes of three ftrands, expreffed in tenth parts of an inch.	Weights ftretching the ropes, expreffed in lb. avoirdupois.	Refiftance about a roller of half an inch diameter, in oz. avoirdupois.	Refiftance about a roller of one inch in diameter, in oz. avoirdupois.	Refiftance about a roller one and a half inch diameter, in oz. avoirdupois.
	lb.	oz.	oz.	oz.
0.5	60	225	112½	75
0.2	60	90	45	30
0.1	60	45	22½	15
0.5	40	150	75	50
0.2	40	60	30	20
0.1	40	30	15	10
0.5	20	75	37½	25
0.2	20	30	15	10
0.1	20	15	7½	*

On the whole, it has been found by experiments, that the difficulty of bending a rope round a roller decreafes directly as the diameter of the roller increafes, or is, inverfely, as the diameter of the roller. See Defaguliers, Experim. Phil. vol. i. p. 233, &c. See alfo Cordage.

A Table, fhewing how many fathoms, feet, and inches of a rope of any fize, under fourteen inches, makes a hundred weight, with the ufe of the table.

Inches.	Fathoms.	Feet.	Inches.	Inches.	Fathoms.	Feet.	Inches.	Inches.	Fathoms.	Feet.	Inches.	Inches.	Fathoms.	Feet.	Inches.
1	486	0	0	4½	24	0	0	8	7	3	6	11½	3	4	1
1¼	313	13	0	4¾	21	3	0	8¼	7	0	8	11¼	3	3	3
1½	216	0	0	5	19	3	0	8½	6	4	3	12	3	2	3
1¾	159	3	0	5¼	17	4	0	8¾	6	2	1	12¼	3	2	1
2	124	3	0	5½	16	1	0	9	6	0	0	12½	3	2	0
2¼	96	2	0	5¾	14	4	6	9¼	5	4	0	12¾	2	7	8
2½	77	3	0	6	13	3	0	9½	5	2	0	13	2	5	3
2¾	65	4	0	6¼	12	2	0	9¾	5	0	6	13¼	2	4	9
3	54	0	0	6½	11	3	0	10	4	5	0	13½	2	4	0
3¼	45	5	2	6¾	10	4	0	10¼	4	4	1	13¾	2	3	6
3½	39	3	0	7	9	5	6	10½	4	2	2	14	2	2	1
3¾	34	3	9	7¼	9	1	6	10¾	4	1	8				
4	30	1	6	7½	8	4	0	11	4	0	3				
4¼	26	5	3	7¾	8	3	6	11¼	3	5	7				

Suppofe I want to know how much of eight-inch and quarter rope will make a hundred weight? Find 8¼ under inches, and againft it, in the fixth column, you find 7 0 8, which fhews in a rope of 8¼, there will be feven fathoms eight inches required to make one hundred weight.

A Table, fhewing the weight of any cable or rope of 120 fathoms in length, and for every half inch from three inches to twenty-four in circumference.

Inches.	Cwts.	Qrs.	Inches.	Cwts.	Qrs.	Inches.	Cwts.	Qrs.			Qrs			
3	2	1	7½	14	0	12	36	0	16½	68	0	21	110	1
3½	4	0	8	16	0	12½	39	0	17	72	1	21½	115	2
4	4	1	8½	18	0	13	42	1	17½	76	2	22	121	0
4½	5	0	9	20	1	13½	45	7	18	81	0	22½	126	2
5	5	1	9½	22	2	14	49	0	18½	85	2	23	132	1
5½	7	0	10	25	0	14½	52	2	19	90	1	23½	138	0
6	9	0	10½	27	2	15	56	1	19½	95	0	24	144	0
6½	10	2	11	30	1	15½	60	0	20	100	0			
7	10	1	11½	33	0	16	64	0	20½	105	0			

The greateft confumption of rope is ufed for the purpofes of navigation in rigging of fhips: where, though ropes include the whole cordage, there are feveral particularly denominated, and which have particular names given to them; as follow. 1. Awning-ropes are the ridge and fide-ropes. The ridge-rope reeves through the trucks feized along the middle of the awning; the fide-ropes reeve through the trucks feized along the fide of the awning. By thefe ropes the awnings are fpread between the mafts. 2. Bell-rope, nine or ten feet in length, which fplices round a thimble in the eye of the bell-crank. In the middle of the rope is a diamond-knot, and at the end a double wall-knot crowned. 3. Boat-rope, or painter, that by which the boat is towed at the ftern; it fplices with a thimble to a ring-bolt infide the ftem. 4. Bolt-rope, the rope fewed to the edges of the fails, as the head-rope, foot-rope, and leech-rope. 5. Breaft-rope, that faftened along the laniard of the fhrouds, for fafety, when heaving the lead in the chains. 6. Bucket-rope, that which is faftened to the bucket for hauling up water. 7. Buoy-rope, the one faftened to the buoy and crown of the anchor. 8. Davit-rope, the lafhing which fecures the davit to the fhrouds when out of ufe. 9. Entering-ropes have their upper end thruft through the eye in the iron-ftantions at the gangways, and are walled and crowned; and diamond-knots are made at every nine inches afunder in the whole length. 10. Grapnel-rope, that which is bent to the grapnel, by which the boats ride. 11. Guift-rope, that faftened to an eye-bolt in the fhip's fide, and to the outer end of a boom projecting from the fhip's fide, by guys, to keep the boats clear from rubbing againft the fides. 12. Heel-rope, that which hauls out the bowfprit of cutters, and the jib and ftudding-fail boom. 13. Man-ropes are for the fecurity of the men going out upon the bowfprit. 14. Parral-ropes are to connect the ribs and trucks of the parral together. 15. Paffing-ropes lead round the fhip through the eyes in the quarter waift and forecaftle-ftantions, have one end ftopped through the eye of the gangway-ftantion, with a wall-knot crowned, and are fet forward through an eye-bolt in the knight-head with a laniard, having a thimble turned into the end. 16. Ring-ropes are occafionally made faft to the ring or ftopper-bolts in the deck, and by crofs turns round the cable, to confine it more fecurely in ftormy weather. 17. Slip-rope is to trice the bight of the cable into the

heads; a slip-rope is also used in casting off a vessel, till got into the tide's way, &c. 18. Swab-rope is made fast to the eye of the swab, to raise it out of the water. 19. Tiller-ropes are the ropes by which the tiller is worked by means of the steering-wheel. 20. Top-rope is the rope that is reeved through the sheave-hole in the heel of the topmast, to raise it by its tackle to the mast-head. 21. Yard-ropes are only temporarily used to heave the yards on board.

Ropes are distinguished by being either *cable-laid* or *hawser-laid:* the former are composed of nine strands, *viz.* three great strands, each of which is composed of three smaller strands, and each containing an equal number of threads: and a rope, cable-laid, eight inches in circumference, has 333 threads, equally divided, and laid into nine strands: the latter is made with three strands, each of which contains a certain number of rope-yarns, in proportion to the size of the rope required. A rope hawser-laid, eight inches in circumference, has 414 threads, equally divided, and laid into three strands. Thirty fathoms of yarn make eighteen fathoms of rope cable-laid, and so in proportion. Thirty fathoms of yarn make twenty fathoms of rope hawser-laid, and so in proportion. Ropes of from one to two and a half inches in circumference are hawser-laid; of three inches to ten inches, either hawser-laid or cable-laid; and from ten inches to any greater dimension, always cable-laid.

Twice-laid cordage is made of cast rigging, as shrouds, stays, mooring and other cables, which, if not much worn, will make good ropes for netting ships' sides, worming and woolding for cables, spun-yarn for seizing, worming for large stays, seizing for strops of blocks, small cable-laid ropes for warping ships, ratlines, scaffolding-ropes for dock yards, &c.

When the yarn of this old stuff is overhauled, a little thin tar should be poured on it, which will make it pliable and lie better. The yarn unfit for knotting will pick into oakum for caulking.

To open a cable, for making it into small ropes, hang the strands upon three hooks in the tackle-board, stretch it out tight upon the hooks in the sledge, and heave till they are untwisted; then draw out the yarn.

The process of making small ropes is similar to making large ones, except the twisting and closing, which are done by a back-frame wheel or a table-wheel. See the next article.

ROPE-*Making*, the art of preparing hemp, and spinning it into yarns or threads, and twisting those threads into strands, and laying those strands into cordage of the largest size, as the smallest kind is called *cord* or *twine* spinning.

Before we proceed further, it may be necessary to inform our readers of the different sorts of hemp proper to be made use of in the manufacturing of cordage. Of all the hemps yet produced at our English markets, the Russian hemp has proved to be the best; it is grown in the southernmost parts of Russia, and shipped for England from the ports of St. Petersburgh and Riga. The best sort is Riga rhine hemp: the next in quality is termed Petersburgh clean hemp. These two are considered the best sorts of hemp to be used in making the strongest cordage.

The first process in the art of rope-making is, *Hatchelling the Hemp.*

Hatchelling the hemp, is the combing or clearing the ends, which else, in spinning, would run in with the long hemp, and so preparing it ready for the spinner; in the process of which, care and particular attention must be paid by the hatchellers that they do not use too great a quantity of oil, as in such case it will prevent the yarn from imbibing its proper proportion of tar, and thereby prove a serious injury.

N. B. A small quantity of train-oil, say one pint to every hundred weight, sprinkled or daubed with a wad on the hemp, facilitates the hatcheller's business exceedingly, and is very necessary when the hemp is somewhat too dry, as the spinners are better able to perform their business when it has received such assistance.

The second and principal process to be attended to in the manufacturing of cordage, is *Spinning the Yarn.*

In spinning, particular attention must be paid by the spinner that the yarn be spun even, solid, and round; to accomplish which, he must spin with a strong even grip of the hand, taking care not to make his yarn larger in one place than in another, nor make a practice of spinning too much in a hurry; and the spinning-wheel must be kept turning a constant regular pace, otherwise the yarn so spun will lose its principal support, which is its proper turn, or twist, and will be little stronger than a parcel of straight hemp laid together, which would break in warping or straining up. The following regulations must be attended to in spinning. Every spinner is to spin out of the best hemp six threads, one hundred and sixty fathoms long, for a quarter of a day's work; but he is to spin out of the hemp which compose the bands by which the bales of hemp are bound together, no more than four threads, one hundred and sixty fathoms long, for one quarter of a day's work. To every twelve spinners there are allowed two hatchellers, one wheel-turner, and one wheel-tender: the wheel-tender's business is to splice the threads, and wind them on winches. The latter mentioned persons are paid in the same proportions as the spinners, that is, according to what work is done upon the wheel, only with this difference, the spinners are paid seven-pence *per* quarter for their work, the hatchellers, wheel-turner, and wheel-tender, only sixpence.

Each thread of the under-mentioned sizes of yarn to the spinning mark, (*viz.* 160 fathoms,) should weigh as follows:

	lbs.	oz.	drs.		lbs.	oz.	drs.
16	4	0	0	21	3	0	4
17	3	12	4	22	2	14	9
18	3	8	14	23	2	12	8
19	3	5	14	24	2	10	10
20	3	3	3	25	2	8	15

The third process to be attended to in the manufacturing of cordage, is *Warping the Yarn.*

Warping the yarn, is the stretching the yarns, previously to their being tarred, all to one given length, which, in full length rope grounds, is two hundred fathoms, and putting a slight turn or twist into it. The usual method is to warp the yarn either in whole or half hawls, which is done by putting the number of threads you mean to draw down at once in a bite, into a block with one sheave, (the one end of the bite of yarn being fast at the upper end,) which being drawn down and fixed over the end of a hook made fast to a post at one hundred fathoms distance from the warping post, forms, when opened, a length of two hundred fathoms, as above-mentioned. The number of half bites, or blocks of yarn, contained in a whole or half hawl, is to be governed, in a great measure, by the size of the yarn to be warped,—as, for instance, 16 to 19-thread yarn is warped three hundred and thirty-six threads in a hawl, 20 to 25-thread yarn is warped four hundred threads in a hawl. In winding the yarns on the winches after they are spun, it is most usual to wind them on in companies of four in a company; but as that method can-

not always be purfued, it frequently happens that whole or half hawls of yarn are obliged to be warped in half bites of an odd number.

The following rules and regulations refpecting the warping of yarn muft be particularly attended to.

In a hawl of yarn containing three hundred and thirty-fix threads, there fhould be warped as under-mentioned.

½ Bites.	Threads.			
37	3	of	9	threads in a ½ bite.
33	6		10	ditto.
30	6		11	ditto.
28	0		12	ditto.
25	11		13	ditto.
24	0		14	ditto.
22	6		15	ditto.
21	0		16	ditto.
19	13		17	ditto.
18	12		18	ditto.
17	13		19	ditto.
16	16		20	ditto.

In a hawl of yarn containing four hundred threads, there fhould be warped as under-mentioned.

½ Bites.	Threads.			
44	4	of	9	threads in a ½ bite
40	0		10	ditto.
36	4		11	ditto.
33	9		12	ditto.
30	11		13	ditto.
28	8		14	ditto.
26	10		15	ditto.
25	0		16	ditto.
23	9		17	ditto.
22	4		18	ditto.
21	1		19	ditto.
20	0		20	ditto.

When the yarn is warped in half hawls, it is to be carefully obferved that only half the number of yarns, or threads, above-mentioned, are to be warped, and care fhould be taken to warp the number of threads as near as poffible.

It requires three men to warp a hawl of yarn, who are employed as follows: *viz.* two men to warp (or draw the yarns to their proper diftance), and one man to fet up (that is, to tighten the yarns, and bring each yarn to its proper bearing): each man is allowed twelve threads (or two quarters of a day's work) for his labour.

To take the hawl of yarn up after it is warped, and carry the fame into the tar-houfe, requires ten men, who are each paid one thread (*viz.* one penny) for their labour.

The fourth procefs to be attended to in the manufacturing of cordage, is *Tarring the Yarn.*

Tarring the yarn is a procefs which fhould be particularly attended to, being extremely careful that the tar is not boiling too faft nor too flow; if too faft, the tar will not ftay in the yarn, if not hot enough, the tar will not fufficiently penetrate the yarn; therefore a ftrict medium muft be carefully obferved by the kettle-heater, as well as to keep the horfe, or men, which turn the capftan round, going at a gentle, fteady pace, thereby giving the yarn a proper time to imbibe its neceffary proportion of tar, but at the fame time not fuffering it to be kept in the boiling tar too long, which is apt to make the yarn very tender, therefore fhould be very carefully avoided; and fhould the capftan be ftopped by accident, the ftop that keeps the yarn down muft be inftantly raifed, and the yarn taken out. Particular attention fhould alfo be paid in paying (or coiling) the yarn into the kettle, that too long a length be not payed in at once; if it is fo done, the yarn will, of courfe, touch the bottom of the kettle, which it fhould, by no means, be fuffered to do, as in fuch cafe it will imbibe the dregs and fettlements of the tar appertaining to the bottom of the kettle, and make the yarn in fuch places black, or very much difcoloured, and have a very unpleafing appearance in the rope when made. Yarn for cables requires more tar than for hawfer-laid ropes. For ftanding and running rigging the lefs tar the better, provided the thread is well covered. It fhould be always remembered that the yarn, when tarred, fhould be overfet (or removed) the fame day, as this piece of bufinefs, being omitted, will be likely to prove of a ferious confequence in heating and tendering the yarn, which at all times muft be carefully avoided. In overfetting the yarn it fhould always be remembered that the yarn be well fhook and opened for two or three days, as in fo doing it admits the air, feparates and hardens the yarns, and contributes very much to the ftrength of the cordage. The hawls or half hawls of yarn, when tarred, fhould always be weighed and tallied.

Tarring yarn requires three men, who are employed as follows: *viz.* one to heat the kettle, one to pay (or coil) the yarn in the kettle, and one to haul off and overfet the yarn. They are, in general, paid in proportion to the work the fpinners perform, which is called going by the wheel.

The fifth and laft procefs to be attended to, is *Laying the Cordage.*

In laying cables, and all forts of ropes in general, the great art lies in making each yarn to bear alike. For this purpofe it was, particularly in the larger fized cables, that the patent machines have been introduced. Particular attention muft be paid to this point, as therein confifts the grand principle of making a ftrong rope. For all forts of ropes which are to be immerged in the water, the utmoft care muft be taken to give the ftrands their proper hardnefs in their firft procefs, according to the remarks laid down before, which will prevent the water from penetrating the ftrands, and thereby preferve the infide yarns of the cable; as, if this procefs is not regularly attended to, the infide yarns will be always wet, and very foon decay. It frequently happens that when the yarn is tarred fomewhat too deep, that many a cable is fpoiled, though not intentionally; the fear in the perfon who has the direction in making the cable, of turning a very dark coloured rope out of hand, prevents the regular make being given the cordage, as in preffing the yarn to their proper hardnefs, the tar will fpring out, very much difcolour the rope, and thereby give it a very unpleafing appearance, efpecially when the fun is fhining very hot upon the yarn; to prevent which, in a great meafure, care fhould be taken, in the fummer months, to lay cables, and all forts of cordage in general, either early in the morning, before the fun has much power on the yarn, which is alfo apt to tender it, or late in the evening, after the fun has fet, or gone off the ground, or in heavy weather (by no means rainy); in which cafe your cordage will have a bright pleafing appearance, as the fmall fibres of the hemp will all yield to the top, and lay fmooth, which otherwife would look rough, and appear as if the cordage was made of inferior hemp, though in fact it was not fo, as all forts of hemp have fmall fibres appertaining to them, and which it is paft the art of man to prevent the fun from drawing up, and thereby making the rope look rough and unfeemly.

N. B. The above remarks refpecting taking advantage of the time for laying the cordage are only to be obferved in uncovered grounds.

In *laying cordage*, the yarn for twifting into ftrands is hung on the hooks in the tackle-board, at the upper end of the ground, and upon hooks in the breaft-board of the fledge, at the lower end, which are turned by men at both ends until the ftrands are hard; and are kept up from the ground by the ftake-heads.

Before the turn is put in, the yarn fhould be ftretched to its full extent by means of the tackle fixed from the fledge to the capftern, at twenty yards afunder, at the lower end of the ground; and when ftretched to two hundred fathoms, the prefs is put upon the fledge and drag, before the tackle-fall is caft off; for if the yarn be not properly ftretched before the tackle-fall is caft off, the rope will not be of its fize, nor well made.

The ftrands fhould have a good hardening before the top is put in to lay the rope, and the layer fhould fee that the heavers at the upper end keep the fame hardnefs that the ftrands had before the top fet off, nor fhould he begin to lay the rope until the fledge or wheel is moved by the power of the twift from the upper end.

When twifted fufficiently hard, the ftrands are hung on one hook in the breaft-board of the fledge, but remain feparate on the three hooks at the other end. The top is placed in at the fledge, and the rope twifted by turning the hooks at both ends one way, and, as the rope clofes, the top moves towards the upper end.

When the top is put in, fome of the weight fhould be taken off the fledge or drag, for if laid with as much weight as is ufed in the hardening, it would be too ftiff, but, by removing a part of the weight, the ftrands will couch better.

The ftrength of the men at the hooks being greatly inadequate to the force required for twifting of cables, woolders are ufed, according to the fize of the cable, at equal diftances along the whole length.

Cables fhould be rounded by the lower hook after they are laid, to throw the turn well up. They are generally thought to wear beft when flack-laid; but fome think when fhort-laid.

Cablets ufed for tow-lines or hawfers, require the ftrands to be laid fhorter than cable-ftrands, but not fo fhort-laid in clofing; for being ufed in water, they would become ftiff, hard, unhandy to coil away, and liable to break in cold weather.

In all cable-laid ropes, the proportion of the circumference is to the length of the ftrand in one round, as 11 is to 15; that is, if the circumference be 14½ inches, the length of the ftrand in one circumference is 19¾ inches. In all hawfer-laid rope, the proportion is as 12 to 16; that is, if the circumference be 7 inches, the length of the ftrand in one circumference is near 9⅓.

The ftrength of ropes depends on the hardening or well manufacturing, and not on the bare ftrength of the hemp; for it ftrengthens through every ftage; *viz.* when firft fpun into yarn it is little better than hemp extended; when twifted into ftrands, it fhortens and ftrengthens as above, and increafes in the fame manner when laid into rope.

Where the diameter and circumference of one rope to another is as two to one, that is, where one rope is twice as big as another, the fquare of the diameter is as four to one; which fhews, that one rope has four times as much yarn in it as the other, and confequently is four times as ftrong, according to the different magnitudes.

Cable-laid ropes fhorten as five to three, and hawfer-laid ropes as three to two; confequently the length of the yarn and ftrength will be accordingly; that is, the ftrength will be in the yarn, after it is laid in the rope, as much as if the rope-maker, in fpinning, had allowed the fame quantity of hemp in two feet as he did in three feet, fo that the ftrength communicated by the procefs is two-thirds.

A rope is the fame fize when laid as the yarns were before twifted; fo that what the yarns are leffened by twifting it is made up by fhortening; from which it is inferred, that the yarns are always of an equal bignefs, fince the hemp is the fame at one time as at another, and not any way diminifhed.

Were the ftrands fingle, without being twifted one about another, the ftrength would then be only in proportion as the area of each particular ftrand is in itfelf; but if the ftrands could poffibly be twifted fo as to be directly perpendicular to the bafe, the ftrength would then be found, by multiplying the diameter of the ftrands and the diameter of the whole rope one into the other, and the half of the product would be the ftrength of the faid ftrands; but more particularly take the area of the fingle ftrand and area of the whole cable, and add them together, and the half of that will fhew the ftrength of each ftrand when they are well twifted together.

But as it may be obferved the ftrands lie at a certain angle between a perpendicular and the bafe, fo that, as the angle of incidence is to radius, fo is the relative to the abfolute ftrength.

Refpecting the *Banding of Cordage.*—In the calculations fpecifying the weights of the different lengths of cordage, fuch weights are to be confidered as the neat weights of the rope without bandage.

N. B. To every hundred weight of cordage the manufacturer is allowed to put on four pounds weight of bands; thofe bands are compofed of the fhakings, flyings, and ftrings with which the hemp is tied together, formed into an inferior kind of cordage; but it is to be obferved thofe are all weighed to the rope-makers as good hemp, and paid for accordingly, therefore if he was not allowed to apply the refufe to fuch purpofe, he muft either put a higher price on his cordage, or be a very confiderable lofer. At the fame time it fhould be confidered, that as it is neceffary that every coil of rope fhould be bound together for the convenience of carriage, ftowage, &c. this kind of bandage anfwers fuch purpofe in every degree, as well as if the coils were bound with bands made from the beft hemp.

Table I.

These sizes of Yarn are warped 336 Threads, and from 19 are warped 400 Threads in a Hawl.

	16	17	18	19	20	21	22	23	24	25
	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.
A { Weight of one thread 200 fathoms long. }	5 0 0	4 11 5	4 7 2	4 3 6	4 0 0	3 12 5	3 10 3	3 7 10	3 5 5	3 3 3
B { One-tarred thread 200 fathoms long should weigh from }	6 3 0 to 6 4 0	5 13 3 to 5 14 2	5 8 0 to 5 8 14	5 3 6 to 5 4 3	4 15 3 to 5 0 0	4 11 5 to 4 12 3	4 8 0 to 4 8 11	4 4 14 to 4 5 9	4 2 0 to 4 2 10	3 15 6 to 4 0 0
C { Ten fathoms of each size of B should weigh from }	0 4 $15\frac{1}{4}$ to 0 5 0	0 4 $10\frac{1}{2}$ to 0 4 $11\frac{1}{4}$	0 4 $6\frac{1}{4}$ to 0 4 $6\frac{3}{4}$	0 4 $2\frac{3}{4}$ to 0 4 $3\frac{1}{4}$	0 3 $15\frac{1}{4}$ to 0 4 0	0 3 $12\frac{1}{4}$ to 0 3 13	0 3 $9\frac{1}{2}$ to 0 3 $10\frac{1}{4}$	0 3 7 to 0 3 $7\frac{3}{4}$	0 3 $4\frac{3}{4}$ to 0 3 $5\frac{1}{4}$	0 3 $2\frac{3}{4}$ to 0 3 $3\frac{1}{4}$
	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.
D { Weight of each hawl before tarred. }	15 0 0	14 0 13	13 1 9	12 2 14	14 0 4	13 2 11	12 3 13	12 1 19	11 3 17	11 1 20
E { Weight of each hawl when tarred from }	18 2 7 to 18 3 0	17 1 25 to 17 2 16	16 2 0 to 16 2 18	15 2 15 to 15 3 4	17 2 20 to 17 3 12	16 3 9 to 17 0 0	15 3 19 to 16 0 9	15 1 14 to 15 2 3	14 2 25 to 14 3 14	14 0 16 to 14 1 4

N. B. The calculations of B and C will be found extremely useful, provided the yarn be spun and tarred regular, as by weighing one single yarn, or even ten fathoms, the size of the yarn may be ascertained, without being at the trouble of weighing the hawls.

Table II.

Shewing the Number of Threads to work *per* Hook for three-strand cable-laid Cordage of 6, 12, 18, and 24 Inches in Circumference, of the undermentioned Sizes of Yarn, with the Girt of each Strand, and Weight of each Cable: also the Number of Men required to lay both Strands and Cable, with the Allowance to each Man for his Labour.

The N° of Threads here mentioned weigh 99 lb. to 100 lb.		Sizes of Yarn										Weight of each Cable 120 Fathoms long.	Men for Strands.	Threads *per* Strand.	Men for Cables.	Threads *per* Cable.
		16	17	18	19	20	21	22	23	24	25					
Sizes in Inches.	Girt of Strands.	Threads *per* Hook.										C. qr. lb.				
6	3 [illegible]	18	19	20	21	22	23	24	25	27	28	9 0 0	7	6	15	6
12	$6\frac{1}{2}$ [illegible]	72	76	80	85	89	94	98	103	107	112	36 0 0	17	6	37	8
18	$9\frac{1}{2}$ $\frac{1}{2}$	162	171	181	191	201	211	221	231	242	252	81 0 0	31	8	73	12
24	$12\frac{1}{2}$ [illegible]	288	304	322	340	358	376	394	412	430	448	144 0 0	42	*10	108	18

* Six threads are called a quarter of a day's work, for which each workman is paid 7*d.*, and so on in proportion for a greater or less number.

Remarks and Directions how to apply Tables I. and II.

Example.—Suppose a cable of 12 inches in circumference is wanted to be made, the hawls of yarn out of which, upon examining the weights, are found to weigh 16 cwt. 2 qr. 10 lb. *per* hawl of 336 threads. A reference is to be made to Table I. line E, and the weight, being between 16 cwt. 2 qr. 0 lb. and 16 cwt. 2 qr. 18 lb. will be found to answer to 18-thread yarn. Then look down the 18-thread column, Table II., and upon the line of 12, (the size in the margin,) is found 80 threads *per* hook, which is the number of threads to be laid up *per* hook for the cable to be made of the weight *per* hawl of yarn of 336 threads above specified.

Again, if the hawls of yarn should be tarred of such a weight (say for example) requires to be worked between a 17 and an 18-thread yarn, in such case take the number of threads *per* hook to be worked for the size of the cable demanded, as should be worked both for 17 and 18-thread yarn; add them together, and take half the number of threads so added, to work *per* hook for the cable; but if there should happen in dividing to be an odd thread remaining, you must observe to which side the weight of your hawl of yarn is most inclining, and throw the thread in dispute to the heaviest side. The same rules must be observed in consulting all the following tables.

Remarks.—In laying three-strand cable-laid cordage, if you are in doubt respecting the size of your yarn, you must girt the yarn you purpose laying in one strand, and that should be half the size of your cable.

In hardening the strands in the laying of cable-laid

cordage, you muſt work with (in addition to your ſledge) one preſs-barrel to every 20 threads contained in your ſtrand; but in laying the ſtrand, hardening, and laying the cable, you muſt have only one preſs-barrel to every 40 threads contained in your ſtrand or cable. The above is to be conſidered as a ſtanding rule in covered rope-grounds, but in open grounds, the preſs muſt be varied according to the ſtate of the bottom of the ground, which, after a ſhower of rain, or in damp weather, will be naturally ſoft, and occaſion the ſledge to draw exceedingly heavy, and of courſe want the leſs weight of preſs.

N. B. The weight of a preſs-barrel ſhould be from $3\frac{1}{2}$ to 4 cwt.

Table III.

Shewing the different ſhrinking Proportions of the Yarns and Strands in each Proceſs in making the undermentioned Lengths of Cable.

	Length in fathoms of cable.	Length of yarns required to be warped.		In hardening the ſtrands, the yarn will ſhrink 1-5th part of the whole length warped, and is called the ſtrand's hardening mark.		In laying the ſtrands, the ſtrand will ſhrink 1-10th part of the whole length warped, and is called the ſtrand's going diſtance.		In hardening the cable-ſtrands previous to laying the cable, the ſtrands will ſhrink 1-30th part of the whole length warped, and is called the cable's hardening mark.			In laying the cable it will ſhrink 1-15th part of the whole length warped, which brings it to the length required.
	The Sledge ſhould move up to the following Diſtances from the Tackle-Poſts.										
	fms.	fms.	ft.	fms.	ft.	fms.	ft.	fms.	ft.	in.	fms.
⅓ Cable	40	66	4	53	2	46	4	44	2	8	40
	60	100	0	80	0	70	0	66	4	0	60
	80	133	2	106	4	93	2	88	5	4	80
Whole	120	200	0	160	0	140	0	133	2	0	120

Table IV.

Shewing the Weights of three-ſtrand cable-laid Cordage.

	fms.	3-Inch Cable.	6-Inch Cable.	9-Inch Cable.	12-Inch Cable	15-Inch Cable.	18-Inch Cable	21-Inch Cable.	24-Inch Cable.
		C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.
⅓ Cable	40	0 3 0 0	3 0 0 0	6 3 0 0	12 0 0 0	18 3 0 0	27 0 0 0	36 3 0 0	48 0 0 0
½	60	1 0 14 0	4 2 0 0	10 0 14 0	18 0 0 0	28 0 14 0	40 2 0 0	55 0 14 0	72 0 0 0
⅔	80	1 2 0 0	6 0 0 0	13 2 0 0	24 0 0 0	37 2 0 0	54 0 0 0	73 2 0 0	96 0 0 0
Whole	120	2 1 0 0	9 0 0 0	20 1 0 0	36 0 0 0	56 1 0 0	81 0 0 0	110 1 0 0	144 0 0 0

It is neceſſary to be underſtood, that in rope-making (according to the nature of the rope), weight will give ſize, and ſize will give weight, if properly made.

Rule.—To calculate very nearly the weight of any ſized rope from 3 to 24 inches in circumference, 120 fathoms long, and leſſer lengths in proportion; as may be readily proved by the above table, *viz.* multiply the ſize of the rope by itſelf, and one-fourth of that product is the weight of a hundred of 112 pounds.

Example.—Suppoſe the rope 12 inches in circumference; 12 × 12 :: 144, the fourth of which is 36 hundred weight, or 3732 pounds, the weight of 120 fathoms of rope 12 inches in circumference. Again, 40 fathoms is the third of 120 fathoms; and the third of 36 cwt. is 12 cwt. the weight of 40 fathoms of 12-inch cable, as above.

Directions how to apply the following Tables.

In which is conſidered the four moſt principal ſorts of yarns made uſe of in cable-laid cordage, *viz.* 16, 18, 20, and 25-thread yarn, and in hawſer-laid cordage, to the three principal ſorts of yarn made uſe of, *viz.* 18, 20, and 25-thread yarn, as it is very ſeldom any other ſize yarn is made for either cable or hawſer-laid rope, except very particularly ordered to the contrary. The particulars of every rope of the ſizes mentioned in the tables are fully explained to the length of twenty fathoms, which will be found quite a ſufficient guide for a rope of any length required:

As for Example.— Suppoſe I want a taper cable-laid rope to be made out of 16-thread yarn, 60 fathoms long, and 6 inches in circumference, to be tapered ⅔ds the length, and ⅔ds the ſize of the rope. I refer to Table V., and find under the figure 6, (the ſize demanded,) that it muſt be worked 5 threads *per* hook in the ſhank, the length of yarn to be warped for which, for 20 fathoms (I find in the margin) requires to be 33 fathoms 2 feet, three times which is 100 fathoms, the length of yarn required to be warped for the ſhank of a rope of 60 fathoms long. I then obſerve, in the next column on the right in the margin, the length of yarn required in the head for 20 fathoms is 11 fathoms 0 feet 8 inches, three times which is 33 fathoms 2 feet, the length of yarn required in the head to the firſt taper for a rope of 60 fathoms. Next refer to the number of tapers to be worked, which, upon looking under the figure 6, (the ſize demanded,) I find to be 9, the diſtance between them I find (upon caſting my eye down the column) to be 14 feet $7\frac{1}{4}$ inches for 20 fathoms, three times which is 44 feet $5\frac{1}{4}$ inches, the diſtance to be obſerved between the tapers for a rope of 60 fathoms, being the length demanded. The ſame rule is be obſerved, either adding or multiplying, according as required in all the tables of a ſimilar deſcription.

TABLE V.

Shewing the Number of Threads to work *per* Hook, both in the Shank and Tapers, in making three-strand taper cable-laid Cordage of the following Sizes, and the Lengths thereto prefixed, with the Lengths of Yarn required to be warped for the same, and the Distance to be observed between the Tapers; for 16, 18, 20, and 25-thread Yarn.

To Taper two-thirds the Length, and two-thirds the Size of the Rope

	Thread Yarn.	Inches. 3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Sizes demanded - -															
Threads *per* hook at the head	16	6	8	10	12	15	18	21	24	28	32	36	40	45	50
	18	7	9	11	14	16	20	23	27	31	36	40	45	50	55
	20	8	9	12	15	18	22	26	30	34	40	45	50	56	62
	25	10	12	16	19	23	28	33	38	43	50	56	63	70	78
Number of threads to be worked in the shank - -	16	2	3	4	4	5	6	7	8	10	11	12	14	15	17
	18	3	3	4	5	6	7	8	9	11	12	14	15	17	19
	20	3	3	4	5	6	8	9	10	12	14	15	17	19	22
	25	4	5	6	7	8	10	11	13	15	17	19	21	24	26
Number of threads to be worked in the tapers - -	16	4	5	6	8	10	12	14	16	18	21	24	26	30	33
	18	4	6	7	9	10	13	15	18	20	24	26	30	33	36
	20	5	6	8	10	12	14	17	20	22	26	30	33	37	40
	25	6	7	10	12	15	18	22	25	28	33	37	42	46	52

Distance between the Tapers.

Fathoms demanded.	Lengths of Yarn in Shank or whole Parts. fms. ft.	Lengths of Yarn in the Head to the first Taper. fms. ft. in.	Lengths of Yarn to Taper. fms. ft. in.	Thread Yarn	ft. in. (3½)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
5	8 2	2 4 8	5 3 4	16	8 4	6 8	5 6 2/3	4 2	3 4	2 9 1/3	2 4 4/7	2 1	1 10 2/9	1 7 1/21	1 4 2/7	1 3 5/13	1 1 1/3	1 0 4/33
10	16 4	5 3 4	11 0 8	16	16 8	13 4	11 1 1/3	8 4	6 8	5 6 2/3	4 9 1/7	4 2	3 8 4/9	3 2 2/21	2 9 1/3	2 6 10/13	2 2 2/3	2 0 8/33
15	25 0	8 2 0	16 4 0	16	25 0	20 0	16 8	12 6	10 0	8 4	7 1 5/7	6 3	5 6 6/9	4 9 3/21	4 2	3 10 2/13	3 4	3 0 12/33
20	33 2	11 0 8	22 1 4	16	33 4	26 8	22 2 2/3	16 8	13 4	11 1 1/3	9 6 2/7	8 4	7 4 8/9	6 4 4/21	6 2 2/7	5 1 7/13	4 5 1/3	4 0 16/33
5	8 2	2 4 8	5 3 4	18	8 4	5 6 2/3	4 9 1/7	3 8 4/9	3 4	2 6 10/13	2 2 2/7	1 10 2/9	1 8	1 4 2/3	1 3 5/17	1 1 1/3	1 0 4/19	0 11 1/9
10	16 4	5 3 4	11 0 8	18	16 8	11 1 1/3	9 6 2/7	7 4 8/9	6 8	5 1 7/13	4 5 1/7	3 8 1/9	3 4	2 9 1/3	2 6 10/17	2 2 2/3	2 0 8/19	1 10 2/9
15	25 0	8 2 0	16 4 0	18	25 0	16 8	14 3 3/7	11 1 3/9	10 0	7 8 4/13	6 8	5 6 6/9	5 0	4 2	3 10 2/17	3 4	3 0 12/19	2 9 3/9
20	33 2	11 0 8	22 1 4	18	33 4	22 2 2/3	19 0 4/7	14 9 7/9	13 4	10 3 1/13	8 10 2/7	7 5 5/9	6 8	5 6 2/3	5 1 7/17	4 5 1/3	4 0 16/19	3 8 4/9
5	8 2	2 4 8	5 3 4	20	6 8	5 6 2/3	4 2	3 4	2 9 1/3	2 4 4/7	1 11 9/17	1 8	1 6 2/11	1 3 5/13	1 1 1/3	1 0 4/19	0 10 30/37	0 10
10	16 4	5 3 4	11 0 8	20	13 4	11 1 1/3	8 4	6 8	5 6 2/3	4 9 1/7	3 11 1/17	3 4	3 0 4/11	2 6 10/13	2 2 2/3	2 0 8/19	1 9 23/37	1 8
15	25 0	8 2 0	16 4 0	20	20 0	16 8	12 6	10 0	8 4	7 1 5/7	5 10 10/17	5 0	4 6 6/11	3 10 2/13	3 4	3 0 12/19	2 8 16/37	2 6
20	33 2	11 0 8	22 1 4	20	26 8	22 2 2/3	16 8	13 4	11 1 1/3	9 6 2/7	7 10 2/17	6 8	6 0 8/11	5 1 7/13	4 5 1/3	4 0 16/19	3 7 9/37	3 4
5	8 2	2 4 8	5 3 4	25	5 6 2/3	4 9 1/7	3 4	2 9 1/3	2 2 2/3	1 10 2/9	1 6 2/11	1 4	1 2 2/7	1 0 4/35	0 10 30/37	0 9 11/21	0 8 16/23	0 8 2/11
10	16 4	5 3 4	11 0 8	25	11 1 1/3	9 6 2/7	6 8	5 6 2/3	4 5 1/3	3 8 4/9	3 0 4/11	2 8	2 4 4/7	2 0 8/35	1 9 23/37	1 7 1/21	1 5 9/23	1 4 4/11
15	25 0	8 2 0	16 4 0	25	16 8	14 3 3/7	10 0	8 4	6 8	5 6 6/9	4 6 6/11	4 0	3 6 6/7	3 0 12/35	2 8 16/37	2 4 12/21	2 2 2/23	2 0 6/11
20	33 2	11 0 8	22 1 4	25	22 2 2/3	19 0 4/7	13 4	11 1 1/3	8 10 2/3	7 5 5/9	6 0 8/11	5 4	4 9 1/7	4 0 16/35	3 7 9/37	3 2 2/21	2 10 18/23	2 8 8/11

TABLE V.—*continued.*

To Taper half the Length and half the Size of the Rope.

	Thread Yarn.	Inches. $3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10
Sizes demanded - -															
Threads *per* hook at the head	16	6	8	10	12	15	18	21	24	28	32	36	40	45	50
	18	7	9	11	14	16	20	23	27	31	36	40	45	50	55
	20	8	9	12	15	18	22	26	30	34	40	45	50	56	62
	25	10	12	16	19	23	28	33	38	43	50	56	63	70	78
Number of threads to be worked in the shank -	16	3	4	5	6	8	9	11	12	14	16	18	20	23	25
	18	4	5	6	7	8	10	12	14	16	18	20	23	25	28
	20	4	4	6	8	9	11	13	15	17	20	23	25	28	32
	25	5	6	8	10	12	14	17	19	22	25	28	31	35	39
Number of threads to be worked in the tapers - -	16	3	4	5	6	7	9	10	12	14	16	18	20	22	25
	18	3	4	5	7	8	10	11	13	15	18	20	22	25	27
	20	4	5	6	7	9	11	13	15	17	20	22	25	28	30
	25	5	6	8	9	11	14	16	19	21	25	28	32	35	39

Fathoms demanded.	Lengths of Yarn in Shank or whole Parts.	Lengths of Yarn in the Head to the first Taper.	Lengths of Yarn to Taper.	Diſtance between the Tapers.														
	fms. ft.	ft	ft.		ft. in.													
5	8 2	25	25	16	8 4	6 3	5 0	4 2	3 $6\frac{6}{7}$	2 $9\frac{1}{3}$	2 6	2 1	1 $9\frac{3}{7}$	1 $6\frac{3}{4}$	1 $4\frac{2}{3}$	1 3	1 $1\frac{7}{11}$	1 0
10	16 4	50	50		16 8	12 6	10 0	8 4	7 $1\frac{5}{7}$	5 $6\frac{2}{3}$	5 0	4 2	3 $6\frac{6}{7}$	3 $1\frac{1}{2}$	2 $9\frac{1}{3}$	2 6	2 $3\frac{3}{11}$	2 0
15	25 0	75	75		25 0	18 9	15 0	12 6	10 $8\frac{4}{7}$	8 4	7 6	6 3	5 $4\frac{2}{7}$	4 $8\frac{1}{4}$	4 2	3 9	3 $4\frac{10}{11}$	3 0
20	33 2	100	100		33 4	25 0	20 0	16 8	14 $3\frac{3}{7}$	11 $1\frac{1}{3}$	10 0	8 4	7 $1\frac{5}{7}$	6 3	5 $6\frac{2}{3}$	5 0	4 $6\frac{6}{11}$	4 0
5	8 2	25	25	18	8 4	6 3	5 0	3 $6\frac{6}{7}$	3 $1\frac{1}{2}$	2 6	2 $3\frac{3}{11}$	1 $11\frac{1}{13}$	1 8	1 $4\frac{2}{3}$	1 3	1 $1\frac{7}{11}$	1 0	0 $11\frac{1}{9}$
10	16 4	50	50		16 8	12 6	10 0	7 $1\frac{5}{7}$	6 3	5 0	4 $6\frac{6}{11}$	3 $10\frac{2}{13}$	3 4	2 $9\frac{1}{3}$	2 6	2 $3\frac{3}{11}$	2 0	1 $10\frac{2}{9}$
15	25 0	75	75		25 0	18 9	15 0	10 $8\frac{4}{7}$	9 $4\frac{1}{2}$	7 6	6 $9\frac{9}{11}$	5 $9\frac{3}{13}$	5 0	4 2	3 9	3 $4\frac{10}{11}$	3 0	2 $9\frac{3}{9}$
20	33 2	100	100		33 4	25 0	20 0	14 $3\frac{3}{7}$	12 6	10 0	9 $1\frac{1}{11}$	7 $8\frac{4}{13}$	6 8	5 $6\frac{2}{3}$	5 0	4 $6\frac{6}{11}$	4 0	3 $8\frac{4}{9}$
5	8 2	25	25	20	6 3	5 0	4 2	3 $6\frac{6}{7}$	2 $9\frac{1}{3}$	2 $3\frac{3}{11}$	1 $11\frac{1}{13}$	1 8	1 $5\frac{11}{17}$	1 3	1 $1\frac{7}{11}$	1 0	0 $10\frac{5}{7}$	0 10
10	16 4	50	50		12 6	10 0	8 4	7 $1\frac{5}{7}$	5 $6\frac{2}{3}$	4 $6\frac{6}{11}$	3 $10\frac{2}{13}$	3 4	2 $11\frac{5}{17}$	2 6	2 $3\frac{3}{11}$	2 0	1 $9\frac{3}{7}$	1 8
15	25 0	75	75		18 9	15 0	12 6	10 $8\frac{4}{7}$	8 4	6 $9\frac{9}{11}$	5 $9\frac{3}{13}$	5 0	4 $4\frac{16}{17}$	3 9	3 $4\frac{10}{11}$	3 0	2 $8\frac{1}{7}$	2 6
20	33 2	100	100		25 0	20 0	16 8	14 $3\frac{3}{7}$	11 $1\frac{1}{3}$	9 $1\frac{1}{11}$	7 $8\frac{4}{13}$	6 8	5 $10\frac{10}{17}$	5 0	4 $6\frac{6}{11}$	4 0	3 $6\frac{6}{7}$	3 4
5	8 2	25	25	25	5 0	4 2	3 $1\frac{1}{2}$	2 $9\frac{1}{3}$	2 $3\frac{3}{11}$	1 $9\frac{3}{7}$	1 $6\frac{3}{4}$	1 $3\frac{15}{19}$	1 $2\frac{2}{7}$	1 0	0 $10\frac{5}{7}$	0 $9\frac{3}{8}$	0 $8\frac{4}{7}$	0 $7\frac{9}{13}$
10	16 4	50	50		10 0	8 4	6 3	5 $6\frac{2}{3}$	4 $6\frac{6}{11}$	3 $6\frac{6}{7}$	3 $1\frac{1}{2}$	2 $7\frac{11}{19}$	2 $4\frac{4}{7}$	2 0	1 $9\frac{3}{7}$	1 $6\frac{6}{8}$	1 $5\frac{1}{7}$	1 $3\frac{5}{13}$
15	25 0	75	75		15 0	12 6	9 $4\frac{1}{2}$	8 4	6 $9\frac{9}{11}$	5 $4\frac{2}{7}$	4 $8\frac{1}{4}$	3 $11\frac{7}{19}$	3 $6\frac{6}{7}$	3 0	2 $8\frac{1}{7}$	2 $4\frac{1}{8}$	2 $1\frac{5}{7}$	1 $11\frac{1}{13}$
20	33 2	100	100		20 0	16 8	12 6	11 $1\frac{1}{3}$	9 $1\frac{1}{11}$	7 $1\frac{5}{7}$	6 3	5 $3\frac{3}{19}$	4 $9\frac{1}{7}$	4 0	3 $6\frac{6}{7}$	3 $1\frac{4}{8}$	2 $10\frac{2}{7}$	2 $6\frac{10}{13}$

Table VI.

Shewing the Number of Threads to work *per* Hook and Heart for cable-laid Stays, four Strands and a Heart, of 5, 10, 15, and 19 Inches in Circumference, of the undermentioned Sizes of Yarn, with the Girt of each Strand prefixed againſt each Size.

Number of Threads aſunder to weigh from 99 to 100lb.		16	17	18	19	20	21	22	23	24	25
Size in Inches.	Girt of each Strand.	Threads *per* Hook and Heart.									
5	2 $\frac{4}{9}$	9	9	10	11	11	12	12	13	13	14
10	4$\frac{1}{4}$ $\frac{7}{9}$	35	37	39	41	43	46	48	50	52	55
15	6$\frac{1}{2}$ $\frac{6}{9}$	79	84	89	94	99	104	109	114	119	124
19	8$\frac{1}{4}$ $\frac{7}{9}$	127	135	143	151	159	167	175	183	191	199

The ſhrinking proportions of cable-laid ſtays are exactly the ſame as in three-ſtrand cable-laid cordage, except in the cloſing the ſtay, which being compoſed of four ſtrands, lie much cloſer in the rope than three ſtrands, and having the heart of the ſtay to encompaſs, occaſions the ſtrands to ſhorten in a much greater proportion than in three-ſtrand cable-laid cordage. The ſtay, in cloſing, will ſhorten $\frac{2}{11}$ parts of the length of yarn firſt warped.

Table VII.

Shewing the Weight of cable-laid Stays, four Strands and a Heart, from 5 to 19 Inches in Circumference, and from 5 to 30 Fathoms in Length.

Fathoms in Length.	5-Inch Stay.				7-Inch Stay.				9-Inch Stay.				11-Inch Stay.				13-Inch Stay.				15-Inch Stay.				17-Inch Stay.				19-Inch Stay.			
	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.	C.	qr.	lb.	oz.
5	0	1	3	9	0	2	4	5	0	3	16	10	1	1	9	11	1	3	17	2	2	2	2	3	3	0	25	9	4	0	7	10
10	0	2	7	2	1	0	8	10	1	3	5	4	2	2	19	6	3	3	6	4	5	0	4	6	6	1	23	2	8	0	15	4
15	0	3	10	11	1	2	12	15	2	2	21	14	4	0	1	1	5	2	23	6	7	2	6	9	9	2	20	11	12	0	22	14
20	1	0	14	4	2	0	17	4	3	2	10	8	5	1	10	12	7	2	12	8	10	0	8	12	12	3	18	4	16	1	2	8
25	1	1	17	13	2	2	21	9	4	1	27	2	6	2	20	7	9	2	1	10	12	2	10	15	16	0	15	13	20	1	10	2
30	1	2	21	6	3	0	25	14	5	1	15	12	8	0	2	2	11	1	18	12	15	0	13	2	19	1	13	6	24	1	17	12

Table VIII.

Shewing the Number of Threads to work *per* Hook for four-ſtrand cable-laid Cordage without a Heart, from 5 to 24 Inches in Circumference, of the Sizes of Yarn undermentioned, with the Weight of each Cable prefixed.

No. of Threads weighing from 99 to 100lb.	16	17	18	19	20	21	22	23	24	25	Weight of each Cable 120 Fathoms long.		
Size in Inches.	Threads *per* Hook.										C.	qr.	lb.
5	9	10	10	11	12	12	13	13	14	15	6	2	10
10	38	40	42	45	47	50	52	54	57	59	25	3	6
15	85	91	96	101	107	112	118	123	128	134	58	3	0
20	152	162	171	181	190	200	209	219	228	238	104	1	9
24	219	233	247	260	274	288	301	315	329	343	150	1	2

Table IX.

Shewing the Length of Yarn required to be warped, and the different ſhrinking Proportions in making the undermentioned Lengths of four-ſtrand cable-laid Cordage.

Fathoms demanded.	Lengths of Yarn warped.			Strand's Hardening Mark.			Strand's Going Diſtance.			Cable's Hardening Mark.			Cable's Length.
	fms.	ft.	in.	fms.	ft.	in.	fms.	ft.	in.	fms.	ft.	in.	
10	17	0	6	13	4	0	11	5	9	11	2	4	10
20	34	1	0	27	2	0	23	5	6	22	4	8	20
40	68	2	0	54	4	0	47	5	0	45	3	4	40
60	102	3	0	82	0	0	71	4	6	68	2	0	60
80	136	4	0	109	2	0	95	4	0	91	0	8	80
120	205	0	0	164	0	0	143	3	0	136	4	0	120

N.B. The ſhrinking proportions of four-ſtrand cable-laid cordage is exactly the ſame as three-ſtrand, except in cloſing the cable, which conſiſting of four ſtrands, lie much cloſer in the rope than three ſtrands, but not having a heart to encompaſs it, does not diminiſh in length ſo much as cable-laid ſtays. The cable in cloſing will ſhorten $\frac{10}{135}$ parts of the length of yarn firſt warped.

It being rather unuſual to lay cables with a greater number of ſtrands than four, the above tables are not laid down for a greater proportion,—but to know how to find the number of threads to work *per* hook for a greater number may at ſome time be neceſſary, therefore the following method muſt be purſued to lay a cable in as many ſtrands as may be thought expedient. Suppoſe a five-ſtrand cable-laid rope is wanted to be made, you firſt ſquare the ſize of the rope propoſed to be made, and multiply that product by the ſize yarn you mean to make your cable from, that product divide by 52, and the quotient will be the number of threads to work *per* hook for a five-ſtrand cable-laid rope. If for a ſix-ſtrand, proceed as before, and divide by 62; for a ſeven-ſtrand, divide by 72; for an eight-ſtrand, divide by 82; and ſo on, adding 10 to your diviſor for every ſtrand you mean to increaſe in number in your cable.

Table X.

Shewing the Prime Coſt to the Manufacturer in each Proceſs, in making the undermentioned Sizes of three-ſtrand cable-laid Cordage, with the Weight of Hemp and Tar required for each Rope.

Size.	Hatchelling, Wheel-turning, and Tending.		Expence at 6*d.* *per* Quarter			Spinning.		Expence at 7*d.* *per* Quarter.			Warping, Taking-up, and Tarring, at 9*s.* *per* Hawl.			Laying at 7*d.* *per* Quarter.			Total Expence of Manufacturing into Cordage.			Weight of Hemp required for each Rope.			Weight of Tar required for each Rope.		
In.	qr.	thds.	*L.*	*s.*	*d.*	qr.	thds.	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	C.	qr.	lb.	C	qr.	lb.
5	7	3	0	3	9	22	3	0	13	1	0	2	10½	0	15	5	1	15	1½	5	0	0	1	1	0
10	31	1½	0	15	7½	93	4½	2	14	7½	0	12	1	2	6	1	6	8	5	20	0	0	5	0	0
15	70	3¾	1	15	3¾	211	5¼	6	3	6¼	1	7	3	5	17	10	15	3	11	45	0	0	11	1	0
20	125	0	3	2	6	375	0	10	18	9	2	8	2	11	18	0	28	7	5	80	0	0	20	0	0
24	180	0	4	10	0	540	0	15	15	0	3	9	5	15	11	6	39	5	11	115	0	23	28	3	5

The above table is calculated according to the uſual mode of rope-making, and is termed by the trade working by the ſquare, which is performed in the following manner: Suppoſe a cable 15 inches in circumference, the ſquare of 15 is 225, the half of which is 112½; that is, 113 threads *per* hook muſt be laid up for a 15-inch cable, proceeding in the ſame manner for any ſize demanded, which mode of working anſwers to ſixteen-thread yarn in all ſizes of three-ſtrand cable-laid cordage.

Where the diameter and circumference of one rope to another is as 2 to 1, that is, where one rope is twice as big as another, the ſquare of the diameter is as 4 to 1, which ſhews that one rope has four times as much yarn in it as the other, and conſequently is four times as ſtrong, according to the different magnitudes.

Table XI.

Shewing the Number of Threads *per* Hook to work for three-ftrand hawfer-laid Cordage, of 3, 6, 9, and 12 Inches in Circumference, of the Sizes of Yarn undermentioned, with the Weight of each Rope, and the Number of Men required to lay the fame, with the Allowance to each Man for his Labour.

N° of Threads 99 to 100lb. Weight.	16	17	18	19	20	21	22	23	24	25	Weight of each Rope 133.2 long.	Men for Rope.	Threads *per* Rope.
Size in Inches.	Threads *per* Hook.										C. qr. lb.		
3	16	17	18	19	20	21	22	23	24	25	2 2 17	8 0	6
6	64	68	72	76	80	84	88	92	96	100	10 2 12	22 0	12
9	144	153	162	171	180	189	198	207	216	225	23 1 13	37 0	15
12	256	272	288	304	320	336	352	368	384	400	42 1 20	45 0	15

Remarks.—In hardening the ftrands, and in laying hawfer-laid cordage, it muft be worked with (in addition to the weight of the fledge) one prefs-barrel for every twenty threads contained in the rope. This is to be confidered as a ftanding rule in covered rope-grounds, but in open grounds the prefs muft be varied according to the ftate of the ground, as mentioned in cable-laid cordage.

In laying three-ftrand hawfer-laid cordage, if there is any doubt refpecting the fize of the yarn, you muft girt the yarn you propofe laying in two of your readys (or ftrands), and that fhould be juft the fize of the rope.

Table XII.

Shewing the Length of Yarn required to be warped, and the different fhrinking Proportions of the Yarn in each Procefs, in making the undermentioned Lengths of hawfer-laid Rope, and alfo the Weight.

	Fathoms of Rope in Length.	Length of Yarn to be warped.	The Sledge fhould move to the following Marks from the Tackle-Pofts. Rope's Hardening Mark.	Rope's Length.	¾-Inch. Weight.	1½-Inch. Weight.	2-Inch. Weight.	4-Inch. Weight.	6-Inch. Weight.	8-Inch. Weight.	10-Inch. Weight.	12-Inch. Weight.
	fms. ft.	fms.	fms	fms. ft.	qr. lb. oz.	qr. lb. oz.	C. qr lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.
	10 0	15	12	10 0	0 2 7½	0 4 15	0 0 9 14¼	0 1 11 9½	0 3 5 1½	1 1 18 6¼	2 0 23 8	3 0 20 6
	20 0	30	24	20 0	0 4 15	0 9 4	0 0 19 12½	0 2 23 3	1 2 10 3	2 3 8 12½	4 1 19 0	6 1 12 12
	40 0	60	48	40 0	0 9 14	0 19 12	0 1 11 9	1 1 19 6	3 0 20 6	5 2 17 9	8 3 10 0	12 2 25 8
Half Coil	66 4	100	80	66 4	0 16 8	1 5 0	0 2 10 0	2 1 12 0	5 1 6 0	9 1 20 0	14 2 26 0	21 0 24 0
	80 0	120	96	80 0	0 19 12	1 11 8	0 2 23 2	2 3 8 12	6 1 12 12	11 1 7 2	17 2 20 0	25 1 23 0
	100 0	150	120	100 0	0 24 11	1 21 6	0 3 14 14½	3 2 3 15	7 3 22 15	14 0 15 14½	22 0 11 0	31 3 7 12
	120 0	180	144	120 0	1 1 10	2 3 4	1 0 6 11	4 0 26 2	9 2 5 2	16 3 21 11	26 2 2 0	38 0 20 8
Whole Coil	133 2	200	160	133 2	1 5 0	2 10 0	1 0 20 0	4 2 24 0	10 2 12 0	18 3 12 0	29 1 24 0	42 1 20 0

Remarks.—In hardening the ftrands the yarn will fhrink one-fifth of the whole length, which is called the rope's hardening mark.

In laying the rope the ftrands will fhrink one-fixth of the remaining diftance, which brings the rope to the length required.

Table XIII.

Shewing the exact Coft to the Manufacturer in each different Procefs as undermentioned, in making the following Sizes of three-ftrand hawfer-laid Cordage, with the proper Proportions of Hemp and Tar neceffary for each Rope.

Size in Inches.	Hatchel-ing, Wheel turning, and Tend ing.	Expence at 6d. *per* Quarter.	Spinning.	Expence at 7d. *per* Quarter.	Warping, Taking-up, and Tarring Expence at 9s *per* Hawl.	Laying Ex-pence at 7d. *per* Quarter.	Total Expence of manufac-turing into Cordage.	Weight of Hemp re-quired for each Rope.	Weight of Tar required for each Rope.
	qr. thds.	L. s. d.	qr. thds.	L. s. d.	L. s. d.	L. s. d.	L. s. d.	C. qr. lb.	C. qr. lb.
2	1 4	0 0 10	5 0	0 2 11	0 0 7½	0 1 9	0 6 1½	0 3 22	0 0 26
4	6 4	0 3 4	20 0	0 11 8	0 2 7	0 7 0	1 4 7	3 3 23	0 3 21
6	15 0	0 7 6	45 0	1 6 3	0 5 8	1 5 8	3 5 1	8 1 27	2 0 13
8	26 4	0 13 4	80 0	2 6 8	0 10 3	1 15 0	5 5 3	15 0 10	3 3 2
10	41 4	1 0 10	125 0	3 12 11	0 16 1	3 5 7	8 15 5	23 2 10	5 3 14
12	60 0	1 10 0	180 0	5 5 0	1 3 2	3 5 7	11 3 9	33 3 22	8 1 26

The foregoing table is grounded (as termed by the trade) upon the principle of the fquare, but the method of working upon this principle differs between cable and hawfer-laid cordage. The mode purfued for making hawfer-laid cordage is as follows: Suppofe it is wanted to make a three-ftrand hawfer-laid rope, fix inches in circumference; the fquare of 6 is 36, and twice 36 is 72, which is the number of threads to work *per* hook for a fix-inch three-ftrand hawfer-laid rope. The fame method muft be purfued, according to this way of working, for any other fize, and anfwers to eighteen-thread yarn in all three-ftrand hawfer-laid cordage. See Table XI.

Table XIV.

Shewing the Weight of Yarn (of the four moft general Sorts madeufe of) capable of being fpun by each of the following Number of Spinners, at eight Quarters, (or 48 Threads) *per* day, in 1 Day, 1 Week of 6 Days, 1 Month of 24 Days, and 1 Year of 13 Months; with the Yield of Cordage at the Year's End prefixed againft each Number of Spinner's Work.

Numb. of Spinners for		Weight of Yarn *per* Day.	Weight of Yarn *per* Week.	Weight of Yarn *per* Month.	Weight of Yarn *per* Year.	Yield of Cordage.
		Cwt. qrs. lbs.	Cwt. qrs. lbs.	Tons. cwt. qrs. lbs.	Tons. cwt. qrs. lbs.	Tons cwt. qrs. lbs.
16-thread Yarn.	2	3 1 20	20 2 8	4 2 1 4	53 9 2 24	66 17 0 16
	4	6 3 12	41 0 16	8 4 2 8	106 19 1 20	133 14 1 4
	6	10 1 4	61 2 24	12 6 3 12	160 9 0 16	200 11 1 20
	8	13 2 24	82 1 4	16 9 0 16	213 19 3 12	267 8 2 8
	10	17 0 16	102 3 12	20 11 1 20	267 8 0 8	334 5 2 24
	12	20 2 8	123 1 20	24 13 2 24	320 18 1 4	401 2 3 12
18-thread Yarn.	2	3 0 0	18 0 0	3 12 0 0	46 16 0 0	58 10 0 0
	4	6 0 0	36 0 0	7 4 0 0	93 12 0 0	117 0 0 0
	6	9 0 0	54 0 0	10 16 0 0	140 8 0 0	175 10 0 0
	8	12 0 0	72 0 0	14 8 0 0	187 4 0 0	231 0 0 0
	10	15 0 0	90 0 0	18 0 0 0	234 0 0 0	292 10 0 0
	12	17 0 0	108 0 0	21 12 0 0	280 16 0 0	351 0 0 0
20-thread Yarn.	2	2 3 4	16 2 24	3 3 3 12	43 9 0 16	55 2 1 20
	4	5 2 8	33 1 20	6 7 2 24	86 18 1 4	111 0 3 12
	6	8 1 12	50 0 16	9 11 2 8	130 7 1 20	166 3 1 4
	8	11 0 16	66 3 12	12 15 1 20	173 16 2 8	222 1 2 24
	10	13 3 20	83 2 8	15 19 1 4	217 5 2 24	277 4 0 16
	12	16 2 24	100 1 4	19 3 0 16	260 14 3 12	332 6 2 8
25-thread Yarn.	2	2 0 22	13 0 20	2 12 2 24	34 5 1 4	42 16 2 12
	4	4 1 16	26 1 12	5 5 1 20	68 10 2 8	85 13 0 24
	6	6 2 10	39 2 4	7 18 0 16	102 15 3 12	128 9 3 8
	8	8 3 4	52 2 24	10 10 3 12	137 1 0 16	171 6 1 20
	10	10 3 26	65 3 16	13 3 2 8	171 6 1 20	214 3 0 4
	12	13 0 20	79 0 8	15 16 1 4	05 11 2 24	256 19 2 16

N.B. By the above table may be found how much yarn can be fpun by any number of fpinners in any given time whatever.

Table XV.

Shewing the Number of Threads to work *per* Hook, both in the Shank and Tapers, in making three-ſtrand taper hawſer-laid Cordage of the Sizes undermentioned, and the Lengths thereunto prefixed, with the Lengths of Yarn required to be warped for the ſame, and the Diſtance to be obſerved between the Tapers; grounded upon 18, 20, and 25-thread Yarn, and tapered two-thirds the Length, and two-thirds the Size of the Rope.

	Thread Yarn.	Inches. 2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10
Sizes demanded - - -																		
Threads *per* hook at the head -	18	8	12	18	24	32	40	50	60	72	84	98	112	128	144	162	180	200
	20	9	14	20	27	35	45	55	67	80	93	108	125	142	160	180	200	222
	25	11	17	25	34	44	56	69	84	100	117	186	156	177	200	225	250	277
Number of threads to be worked in the ſhank - - - -	18	3	4	6	8	11	14	17	20	24	28	33	38	43	48	54	60	67
	20	3	5	7	9	12	15	19	23	27	31	36	42	48	54	60	67	74
	25	4	6	9	12	15	19	28	28	34	39	46	52	59	67	75	84	93
Number of threads to be worked in the tapers - - -	18	5	8	12	16	21	26	33	40	48	56	65	74	85	96	108	120	133
	20	6	9	13	18	23	30	36	44	53	62	72	63	94	106	120	133	148
	25	7	11	16	22	29	37	46	56	66	78	90	104	118	133	150	166	184

Diſtance between the Tapers.

Fathoms demanded.	Lengths of Yarn in Shank or whole Parts. fms. ft.	Lengths of Yarn in the Head to the firſt Taper. fms. ft.	Lengths of Yarn to Taper. fms.	Thread Yarn	2 ft. in.	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10
5	7 3	2 3	5	18	6 0	3 9	2 6	1 $10\frac{1}{2}$	1 $4\frac{1}{2}$	1 $1\frac{11}{13}$	0 $10\frac{10}{13}$	0 9	0 $7\frac{1}{2}$	0 $6\frac{3}{7}$	0 5[illegible]	0 $4\frac{32}{37}$	0 $4\frac{20}{85}$	0 $3\frac{3}{4}$	0 $3\frac{1}{3}$	0 3	0 $2\frac{94}{111}$
10	15 0	5 0	10	18	12 0	7 6	5 0	3 9	2 $8\frac{4}{9}$	2 3[illegible]	1 9[illegible]	1 6	1 3	1 $0\frac{6}{7}$	0 $11\frac{4}{65}$	0 $9\frac{27}{37}$	0 $8\frac{40}{85}$	0 $7\frac{1}{2}$	0 $6\frac{2}{3}$	0 6	0 $5\frac{77}{111}$
15	22 3	7 3	15	18	18 0	11 3	7 6	5 $7\frac{1}{2}$	4 $1\frac{1}{3}$	3 5[illegible]	2 $5\frac{4}{13}$	2 3	1 $10\frac{1}{2}$	1 $7\frac{2}{7}$	1 $4\frac{40}{65}$	1 $2\frac{22}{37}$	1 $0\frac{60}{85}$	0 $11\frac{1}{4}$	0 10	0 9	0 $8\frac{16}{111}$
20	30 0	10 0	20	18	24 0	15 0	10 0	7 6	5 $5\frac{5}{9}$	4 7[illegible]	3 $7\frac{21}{33}$	3 0	2 6	2 $1\frac{5}{7}$	1 $10\frac{10}{65}$	1 $7\frac{17}{37}$	1 $4\frac{80}{85}$	1 3	1 $1\frac{1}{3}$	1 0	0 $10\frac{112}{111}$
5	7 3	2 3	5	20	5 0	3 4	2 $3\frac{9}{13}$	1 8	1 $3\frac{15}{23}$	1 0	0 10	0 $8\frac{4}{17}$	0 $6\frac{12}{33}$	0 $5\frac{25}{31}$	0 5	0 $4\frac{23}{43}$	0 $3\frac{15}{47}$	0 $3\frac{21}{51}$	0 3	0 $2\frac{94}{133}$	0 $2\frac{16}{37}$
10	15 0	5 0	10	20	10 0	6 8	4 $7\frac{5}{13}$	3 4	2 $7\frac{7}{23}$	2 0	1 8	1 $4\frac{8}{17}$	1 $1\frac{24}{33}$	0 $11\frac{19}{31}$	0 10	0 $8\frac{56}{87}$	0 $7\frac{31}{47}$	0 $6\frac{42}{51}$	0 6	0 $5\frac{85}{133}$	0 $4\frac{32}{37}$
15	22 3	7 3	15	20	15 0	10 0	6 $11\frac{1}{13}$	5 0	3 $10\frac{22}{23}$	3 0	2 6	2 $0\frac{12}{17}$	1 $6\frac{2}{33}$	1 $5\frac{5}{31}$	1 3	1 $1\frac{1}{87}$	0 $11\frac{46}{47}$	0 $10\frac{12}{51}$	0 9	0 $8\frac{16}{133}$	0 $7\frac{13}{37}$
20	30 0	10 0	20	20	20 0	13 4	9 $2\frac{12}{13}$	6 8	5 $2\frac{14}{23}$	4 0	3 4	2 $8\frac{8}{17}$	2 $3\frac{3}{33}$	1 $11\frac{7}{31}$	1 8	1 $5\frac{29}{87}$	1 $3\frac{15}{47}$	1 $1\frac{31}{51}$	1 0	0 $10\frac{110}{133}$	0 $9\frac{27}{37}$
5	7 3	2 3	5	25	4 $3\frac{3}{7}$	2 $8\frac{8}{11}$	1 $10\frac{1}{2}$	1 $4\frac{4}{11}$	1 $0\frac{12}{23}$	0 $9\frac{27}{37}$	0 $7\frac{12}{23}$	0 $6\frac{3}{7}$	0 $5\frac{5}{11}$	0 $4\frac{3}{13}$	0 4	0 $3\frac{6}{13}$	0 $3\frac{1}{13}$	0 $2\frac{94}{133}$	0 $2\frac{10}{25}$	0 $2\frac{14}{83}$	0 $1\frac{22}{23}$
10	15 0	5 0	10	25	8 $6\frac{6}{7}$	5 $5\frac{5}{11}$	3 9	2 $8\frac{8}{11}$	2 $0\frac{24}{23}$	1 $7\frac{17}{37}$	1 $3\frac{13}{23}$	1 $0\frac{6}{7}$	0 $10\frac{10}{11}$	0 $9\frac{3}{13}$	0 8	0 $6\frac{12}{13}$	0 $6\frac{6}{13}$	0 $5\frac{55}{133}$	0 $4\frac{20}{25}$	0 $4\frac{28}{83}$	0 $3\frac{21}{23}$
15	22 3	7 3	15	25	12 $10\frac{2}{7}$	8 $2\frac{2}{11}$	5 $7\frac{1}{2}$	4 $1\frac{1}{11}$	3 $1\frac{13}{23}$	2 $5\frac{7}{37}$	1 $11\frac{14}{23}$	1 $7\frac{2}{7}$	1 $4\frac{4}{11}$	1 $1\frac{11}{13}$	1 0	0 $10\frac{5}{13}$	0 $9\frac{9}{13}$	0 $8\frac{16}{133}$	0 $7\frac{5}{25}$	0 $6\frac{42}{83}$	0 $5\frac{20}{23}$
20	30 0	10 0	20	25	17 $1\frac{5}{7}$	10 $10\frac{10}{11}$	7 6	5 $5\frac{5}{11}$	4 $1\frac{13}{23}$	3 $2\frac{34}{37}$	2 $7\frac{2}{23}$	2 $1\frac{5}{7}$	1 $0\frac{9}{11}$	1 $6\frac{6}{13}$	1 4	1 $1\frac{11}{13}$	1 $0\frac{12}{13}$	0 $10\frac{110}{133}$	0 $9\frac{15}{25}$	0 $8\frac{56}{83}$	0 $7\frac{19}{23}$

TABLE XV.—*continued.*

Tapered half the Length and half the Size of the Rope.

				Thread Yarn.	Inches. 2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Sizes demanded - - -																					
Threads *per* hook at the head -				18	8	12	18	24	32	40	50	60	72	84	98	112	128	144	162	180	200
				20	9	14	20	27	35	45	55	67	80	93	108	125	142	160	180	200	222
				25	11	17	25	34	44	56	69	84	100	117	136	156	177	200	225	250	277
Number of threads to be worked in the shank - - -				18	4	6	9	12	16	20	25	30	36	42	49	56	64	72	81	90	100
				20	5	7	10	14	18	23	28	34	40	47	54	63	71	80	90	100	111
				25	6	9	13	17	22	28	35	42	50	59	68	78	89	100	113	125	139
Number of threads to be worked in the tapers - - -				18	4	6	9	12	16	20	25	30	36	42	49	56	64	72	81	90	100
				20	4	7	11	13	17	22	27	33	40	46	54	62	71	80	90	100	111
				25	5	8	12	17	22	28	34	42	50	58	68	78	88	100	112	125	138
Fathoms demanded.	Lengths of Yarn in Shank or whole Parts.	Lengths of Yarn in the Head to the first Taper.	Lengths of Yarn to Taper.	Distance between the Tapers.																	
	fms. ft.	fms. ft. in.	fms. ft. in.		ft. in.																
5	7 3	3 4 6	3 4 6	18	5 7½	3 9	2 6	1 10½	1 4$\frac{7}{8}$	1 1$\frac{5}{10}$	0 10$\frac{20}{25}$	0 8⅓	0 7½	0 6$\frac{3}{7}$	0 5$\frac{25}{49}$	0 4$\frac{23}{28}$	0 4$\frac{7}{32}$	0 3¾	0 3$\frac{27}{81}$	0 3	0 2$\frac{35}{50}$
10	15 0	7 3 0	7 3 0	18	11 3	7 6	5 0	3 9	2 9$\frac{6}{8}$	2 3	1 9$\frac{15}{25}$	1 4⅔	1 3	1 0$\frac{6}{7}$	0 11$\frac{1}{49}$	0 9$\frac{18}{28}$	0 8$\frac{14}{32}$	0 7½	0 6$\frac{54}{81}$	0 6	0 5$\frac{20}{50}$
15	22 3	11 1 6	11 1 6	18	16 10½	11 3	7 6	5 7½	4 2$\frac{5}{8}$	3 4$\frac{5}{10}$	2 8$\frac{10}{25}$	2 1	1 10½	1 7$\frac{2}{7}$	1 4$\frac{46}{49}$	1 2$\frac{13}{28}$	1 0$\frac{21}{32}$	0 11¼	0 10	0 9	0 8$\frac{5}{50}$
20	30 0	15 0 0	15 0 0	18	22 6	15 0	10 0	7 6	5 7$\frac{4}{8}$	4 6	3 7$\frac{5}{25}$	2 9⅓	2 6	2 1$\frac{5}{7}$	1 10$\frac{2}{49}$	1 7$\frac{8}{28}$	1 4$\frac{28}{32}$	1 3	1 1$\frac{27}{81}$	1 0	0 10$\frac{40}{50}$
5	7 3	3 4 6	3 4 6	20	5 7½	3 2$\frac{3}{7}$	2 3	1 8$\frac{10}{13}$	1 3$\frac{15}{17}$	1 0$\frac{3}{11}$	0 10	0 8$\frac{2}{11}$	0 6$\frac{15}{20}$	0 5$\frac{20}{23}$	0 5	0 4$\frac{11}{31}$	0 3$\frac{57}{71}$	0 3$\frac{15}{40}$	0 3	0 2$\frac{35}{50}$	0 2$\frac{16}{37}$
10	15 0	7 3 0	7 3 0	20	11 3	6 5$\frac{1}{7}$	4 6	3 5$\frac{7}{13}$	2 7$\frac{13}{17}$	2 0$\frac{6}{11}$	1 8	1 4$\frac{4}{11}$	1 1$\frac{10}{20}$	0 11$\frac{17}{23}$	0 10	0 8$\frac{22}{31}$	0 7$\frac{43}{71}$	0 6$\frac{30}{40}$	0 6	0 5$\frac{20}{50}$	0 4$\frac{32}{37}$
15	22 3	11 1 6	11 1 6	20	16 10½	9 7$\frac{5}{7}$	6 9	5 2$\frac{4}{13}$	3 11$\frac{11}{17}$	3 0$\frac{9}{11}$	2 6	2 0$\frac{6}{11}$	1 7$\frac{5}{20}$	1 5$\frac{14}{23}$	1 3	1 1$\frac{2}{31}$	0 11$\frac{29}{71}$	0 10$\frac{5}{40}$	0 9	0 8$\frac{5}{50}$	0 7$\frac{11}{37}$
20	30 0	15 0 0	15 0 0	20	22 6	12 10$\frac{2}{7}$	9 0	6 11$\frac{1}{13}$	5 3$\frac{9}{17}$	4 1$\frac{1}{11}$	3 4	2 8$\frac{8}{11}$	2 2	1 11$\frac{11}{23}$	1 8	1 5$\frac{11}{31}$	1 3$\frac{15}{71}$	1 1$\frac{20}{40}$	1 0	0 10$\frac{40}{50}$	0 9$\frac{27}{37}$
5	7 3	3 4 6	3 4 6	25	4 6	2 9¾	1 10½	1 3$\frac{15}{17}$	1 0$\frac{3}{11}$	0 9$\frac{9}{14}$	0 7$\frac{16}{17}$	0 6$\frac{3}{7}$	0 5$\frac{10}{25}$	0 4$\frac{19}{29}$	0 3$\frac{33}{34}$	0 3$\frac{6}{13}$	0 3$\frac{3}{44}$	0 2$\frac{35}{50}$	0 2$\frac{23}{56}$	0 2$\frac{28}{125}$	0 1$\frac{22}{23}$
10	15 0	7 3 0	7 3 0	25	9 0	5 7½	3 9	2 7$\frac{13}{17}$	2 0$\frac{6}{11}$	1 7$\frac{4}{14}$	1 3$\frac{15}{17}$	1 0$\frac{6}{7}$	0 10$\frac{40}{25}$	0 9$\frac{9}{29}$	0 7$\frac{32}{34}$	0 6$\frac{12}{13}$	0 6$\frac{6}{44}$	0 5$\frac{20}{50}$	0 4$\frac{46}{56}$	0 4$\frac{40}{125}$	0 3$\frac{21}{23}$
15	22 3	11 1 6	11 1 6	25	13 6	8 5¼	5 7½	3 11$\frac{11}{17}$	3 0$\frac{9}{11}$	2 4$\frac{13}{14}$	1 11$\frac{14}{17}$	1 7$\frac{2}{7}$	1 4$\frac{5}{25}$	1 1$\frac{28}{29}$	0 11$\frac{31}{34}$	0 10$\frac{5}{13}$	0 9$\frac{9}{44}$	0 8$\frac{5}{50}$	0 7$\frac{13}{56}$	0 6$\frac{60}{125}$	0 5$\frac{20}{23}$
20	30 0	15 0 0	15 0 0	25	18 0	11 3	7 6	5 3$\frac{9}{17}$	4 1$\frac{1}{11}$	3 2$\frac{8}{14}$	2 7$\frac{13}{17}$	2 1$\frac{5}{7}$	1 9$\frac{15}{25}$	1 6$\frac{18}{29}$	1 3$\frac{20}{34}$	1 1$\frac{11}{13}$	1 0$\frac{12}{44}$	0 10$\frac{40}{50}$	0 9$\frac{36}{56}$	0 8$\frac{80}{125}$	0 7$\frac{19}{23}$

Suppoſe you want to make a rope either cable or hawſer-laid, to be tapered one-third the length, and one-third the ſize; you muſt refer to Table V. or XIV for making taper-cable, or hawſer-laid cordage, two-thirds the length and two-thirds the ſize, which you muſt work almoſt wholly the reverſe way, by working the number of threads there mentioned to be worked in the tapers in the ſhank, and the number of threads in the ſhank muſt be worked in the tapers: the length of yarn there mentioned to be tapered muſt be the length in the head to the firſt taper, and the length there mentioned in the head muſt be the length of the yarn to be tapered: the length of yarn requeſted to be warped for the ſhank will be the ſame as there mentioned, and the diſtance between the tapers will, in almoſt all caſes, be the ſame as there nominated; but if at any time there ſhould be a difference, and you are at a loſs to find the diſtance between the tapers you muſt divide the length of yarn to be tapered by the number of threads you have to taper, and that will give the exact diſtance between them.

Table XVI.

Shewing the Number of Threads to work *per* Hook for four-ſtrand hawſer-laid Cordage, from 2 to 12 Inches in Circumference, of the Sizes of Yarn as undermentioned: the Ropes to be laid without Hearts, the Yarns compriſing which being equally divided in the Strands.

No. of Threads here mentioned to weigh 99 to 100lb.	16	17	18	19	20	21	22	23	24	25
Size in Inches.	Threads *per* Hook.									
2	5	6	6	6	7	7	7	8	8	8
4	22	23	24	25	26	27	29	30	32	33
6	48	51	54	57	60	63	66	69	72	75
8	84	90	96	101	107	112	117	122	128	133
10	133	142	150	158	167	175	183	192	200	208
12	192	204	216	228	240	252	264	276	288	300

Table XVII.

Shewing the Length of Yarn requeſted to be warped for the undermentioned Lengths of four-ſtrand hawſer-laid Cordage, with the Hardening Mark prefixed againſt each reſpective Length.

Fathoms demanded.	Length of Yarn required.			Hardening Mark.		
	fms.	ft.	in.	fms.	ft.	in.
10	15	2	6	12	2	0
20	30	5	0	24	4	0
40	61	4	0	49	2	0
60	92	3	0	74	0	0
80	123	2	0	98	4	0
100	154	1	0	123	2	0
120	185	0	0	148	0	0
130	200	2	6	160	2	0

Remarks.—It is very ſeldom that hawſer-laid cordage is compoſed of more than four ſtrands, but for the ſake of experiment, or otherwiſe, it might be demanded to contain a greater number: as ſuch, the following rule, carefully attended to, will inform our readers how to lay a hawſer-laid rope in as many ſtrands as may be conſidered expedient.

Suppoſe you want a five-ſtrand hawſer-laid rope, you muſt ſquare the ſize of the rope propoſed to be made; that product multiply by the ſize yarn you propoſe making your rope from; the product of which, divided by 15, will give the number of threads to work *per* hook for a five-ſtrand hawſer-laid rope. If you want to make a ſix-ſtrand hawſer-laid-rope, you muſt proceed as above, and divide by 18; if a ſeven-ſtrand, divide by 21; if an eight-ſtrand, by 24; and ſo on, adding 3 to your diviſor for every ſtrand you mean to increaſe in the rope.

The ſhrinking proportion in making four-ſtrand hawſer-laid cordage, in the firſt proceſs, is exactly the ſame as in three-ſtrand; the only difference is in cloſing the rope, which, being compoſed of four ſtrands, occaſions the rope to lay more round and cloſe than in three-ſtrand cordage, which makes the ſhrinkage be in a much greater proportion. The rope, in cloſing, will ſhorten $\frac{1}{16}$th parts of the remaining length of yarn, after the rope is hard, inſtead of $\frac{1}{8}$th, as in three-ſtrand hawſer-laid cordage.

The weight of each coil of four-ſtrand hawſer-laid cordage may be nearly aſcertained, by referring to the table of the weight of three-ſtrand (Table XII.), there being as near the number of threads in each ſize rope as can poſſibly be laid, for each ſtrand to have an equal number. But it ſhould be remembered, that a coil of four-ſtrand hawſer-laid rope, made out of 200 fathoms of yarn, will be only 130 fathoms long, inſtead of 133.2, as in three-ſtrand hawſer laid cordage.

Table XVIII.

Shewing the ſhrinking Proportions of the Yarn, in making the undermentioned Lengths of Bolt-Rope; alſo its Weight (untarred), from 1 to 8 Inches in Circumference.

	Length in Fathoms of Rope demanded.	Length of Yarn required in Fathoms.	The Sledge ſhould move to the following Marks from the Tackle-Poſt, and is called the Rope's Hardening-Mark.		1-Inch. Weight.	2-Inch. Weight.	3-Inch. Weight.	4-Inch. Weight.	5-Inch. Weight.	6-Inch. Weight.	7 Inch. Weight.	8-Inch. Weight.
			Fms.	feet.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.	C. qr. lb. oz.
	10	14	11	4	0 0 2 8¼	0 0 7 11	0 0 16 12¾	0 1 1 5¾	0 1 18 2½	0 2 11 2	0 3 6 10	1 0 7 2½
	20	28	23	2	0 0 5 0½	0 0 15 6	0 1 5 9¼	0 2 2 11½	0 3 8 5	1 0 22 4	1 2 13 4	2 0 14 5
	40	56	46	4	0 0 10 1	0 1 2 12	0 2 11 1½	1 0 5 7	1 2 16 10	2 1 16 8	3 0 26 8	4 1 0 10
	60	84	70	0	0 0 15 1½	0 1 18 2	0 3 16 10	1 2 8 2½	2 1 24 15	3 2 10 12	4 3 11 12	6 1 14 5
	80	112	93	2	0 0 20 2	0 2 5 8	1 0 22 3	2 0 10 14	3 1 5 4	4 3 5 0	6 1 25 0	8 2 1 4
	100	140	116	4	0 0 25 2½	0 2 20 14	1 1 27 11½	2 2 13 9½	4 0 13 9	5 3 27 4	8 0 10 4	10 2 15 9
	120	168	140	0	0 1 2 3	0 3 8 4	1 3 5 4	3 0 16 5	4 3 21 14	7 0 21 8	9 2 23 8	12 3 1 14
Coil	143	200	166	4	0 1 8 0	0 3 26 0	2 0 16 0	3 3 0 0	5 3 16 0	8 2 8 0	11 2 8 0	15 0 24 0

Remarks.—In hardening the ſtrands, the yarn will ſhrink one-ſixth part of the whole length, which is called the rope's hardening mark.

In laying the rope, the ſtrands will ſhrink one-ſeventh part of the remaining diſtance, which brings the rope to the length required.

N. B. Bolt-rope is uſually made of 20 or 25-thread yarn, and generally delivered from the rope-maker white; the proceſs of tarring it being uſually performed by the ſail-maker, and is called ſtoving it, it being done in a ſtove or oven calculated for the purpoſe. In laying up your work, you muſt work with the ſame number of threads as in common hawſer-laid cordage. Bolt-rope, for exportation, is ſometimes lightly tarred; in which caſe, in calculating the weight, you muſt add one-ſixth to the weights hereunto annexed.

Table XIX.

Shewing the Number of Threads to work *per* Hook for three-ſtrand hawſer-laid white Cordage, from 1 to 12 Inches in Circumference, of the undermentioned Sizes of Yarn, with the Weight of each Rope prefixed.

No. of Threads here mentioned to weigh 88 lbs.	16	17	18	19	20	21	22	23	24	25	Weight of each Rope 133.2 Fathoms long.
Size in Inches.	Threads *per* Hook.										C. qr. lb.
1	3	3	3	3	3	3	3	4	4	4	0 1 12
2	8	8	9	9	10	10	10	11	12	12	1 0 8
3	18	19	20	21	22	23	24	25	26	27	2 1 12
4	32	33	35	37	39	41	42	44	46	48	4 0 20
6	72	76	80	84	88	92	96	100	104	108	9 1 20
8	128	135	142	149	156	163	170	177	185	192	16 2 24
10	200	211	222	233	244	255	266	277	289	300	26 0 16
12	288	304	320	336	352	368	384	400	416	432	37 2 24

N. B. Eſpecial care ſhould be taken relative to making white cordage for tackle-falls, crane-ropes, &c. that the hemp be of the very beſt quality; and that the ſame be topped, *viz.* all the ſhort hemp taken out by the hatcheller; and that the ſpinner do ſpin his yarn for the ſame exceeding ſmart and even, by no means lighter than the weight ſpecified under the article *ſpinning the yarn:* if he does, his rope will not anſwer the ſize required to be made.

TABLE XX.

Shewing the Number of Threads to work *per* Hook for four-ſtrand hawſer-laid white Cordage, without Hearts, from 2 to 12 Inches in Circumference, of the Sizes of Yarn as undermentioned.

No. of Threads here mentioned to weigh 88 lbs.	16	17	18	19	20	21	22	23	24	25
Size in Inches.	Threads *per* Hook.									
2	6	6	7	7	7	8	8	8	9	9
3	13	14	15	15	16	17	18	19	19	20
4	24	25	26	27	29	30	32	33	35	36
5	37	39	41	43	45	47	49	51	54	56
6	54	57	60	63	66	69	72	75	78	81
8	96	101	107	112	117	122	128	133	139	144
10	150	158	167	175	183	192	200	208	217	225
12	216	228	240	252	264	276	288	300	312	324

N. B. The weight of the above ropes may be found by conſulting Table XVII. for three-ſtrand hawſer-laid white cordage; the number of threads in each rope of a ſize being of an equal number, as near as poſſible.

Cordage made by Contract for the Uſe of His Majeſty's Navy.—The under-mentioned ſhews the number of threads to work *per* hook; the loweſt weight, allowance in weight, bandage, and higheſt weight; the cordage is to be received and allowed for by the receiving officers of his majeſty's reſpective dock-yards, under the honourable commiſſioners of his majeſty's navy, to rope-makers who have made cordage (upon the uſual principle) by contract, in coils, hawſers, cablets, and cables, with the length of yarn to be warped for the ſame, and length of cordage when made, as ordered by the honourable navy-board.

N. B. The higheſt weight a hawl of yarn for each ſort of cordage ſhould weigh (and by no means more,) is here noted.

TABLE XXI. Cablets.

Size	Threads *per* Hook.	Loweſt Weight.	Allowance in Weight.	Bandage.	Higheſt Weight.
		C. qr lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.
2	3	1 1 4	0 0 4	0 0 4	1 1 12
2½	4	1 3 0	0 0 5	0 0 5	1 3 10
3	6	2 2 1	0 0 7	0 0 8	2 2 16
3½	8	3 1 2	0 0 10	0 0 11	3 1 23
4	10	4 0 18	0 0 12	0 0 13	4 1 15
4½	12	5 0 23	0 0 15	0 0 16	5 1 26
5	15	6 2 1	0 0 18	0 0 20	6 3 11
5½	18	7 3 7	0 0 22	0 0 24	8 0 25
6	21	9 0 12	0 0 26	0 1 0	9 2 10
6½	24	10 1 19	0 1 1	0 1 4	10 3 24
7	28	12 0 18	0 1 6	0 1 9	12 3 5
7½	32	13 3 16	0 1 11	0 1 14	14 2 13
8	37	16 0 6	0 1 17	0 1 21	16 3 16
8½	42	18 0 27	0 1 23	0 2 0	19 0 22
9	47	20 1 17	0 2 1	0 2 7	21 1 25
9½	52	22 2 9	0 2 7	0 2 13	23 3 1

It is to be obſerved, that the above ſizes in Tab. XX., *viz.* 2 to 9½ inches, are termed, in the navy contracts, cablets, the yarn for which ſhould be warped 200 fathoms long, and the cablets, when complete, to be 120 fathoms. A hawl of yarn containing 336 threads, ſhould weigh from 16 cwt. 0 qr. 8 lb. to 16 cwt. 1 qr. 25 lb., and no more, allowing one-ſixth part of ſuch weight for tar, which is the allowance made by the honourable navy-board, and no more.

TABLE XXII. Cables.

Size.	Threads *per* Hook.	Loweſt Weight.	Allowance in Weight.	Higheſt Weight.
		C. qr. lb.	C. qr. lb.	C. qr. lb.
10	58	21 0 23	0 2 3	21 2 26
10½	64	23 1 17	0 2 9	23 3 26
11	70	25 2 10	0 2 15	26 0 25
11½	76	27 3 4	0 2 22	28 1 26
12	83	30 1 10	0 3 1	31 0 11
12½	90	32 3 17	0 3 8	33 2 25
13	98	35 3 9	0 3 16	36 2 25
13½	106	38 3 1	0 3 25	39 2 26
14	114	41 2 20	1 0 5	42 2 25
14½	122	44 2 12	1 0 12	45 2 24
15	130	47 2 3	1 0 21	48 2 24
15½	139	50 3 7	1 1 2	52 0 9
16	148	54 0 13	1 1 11	55 1 24
16½	157	57 1 16	1 1 20	58 3 8

Cablets from 4 to 9½ inches will not be rejected, if they are half an inch in girt above the dimenſions ordered.

The yarn for the above cables (Tab. XXII.) are warped 166 fms. 4 ft. long, and the cables, when complete, to be 100 fathoms long. A hawl of yarn containing 336 threads, 166 fms. 4 ft. long, ſhould weigh from 13 cwt. 2 qr. 6 lb. to 13 cwt. 3 qr. 16 lb., and no more, tarred with the ſame proportion of tar as the yarn for the cablets before-mentioned.

Cables 10 inches and upwards, are allowed three-fourths of an inch in girt more than the dimensions given.

In proportions of cordage wherein the cables contained in them do not exceed $13\frac{1}{2}$ inches in circumference, a proportion of $1\frac{1}{2}$ cwt. of spun-yarn is allowed to be sent to every ton of cordage; but if the cables are 14 inches in circumference and upwards, then 3 cwt. for every ton is allowed, in order to work up the toppings (or hemp) which should be taken out of the hemp agreeable to contract, previous to its being spun into cable-yarn (in particular), as it frequently happens that the great number of lives of some of his majesty's most valuable subjects are at stake upon the dependance of a single cable.

The cables made in the usual mode, by contract, have of late never exceeded $16\frac{1}{2}$ inches in circumference, (Tab. XXII. extends no further): for all the higher sizes are made by patent machines, by which much manual labour is spared, and the yarns and strands laid much closer and more even, and bear the strain more equally.

Size.	Threads per Hook.	Lowest Weight.	Allowance in Weight.	Bandage.	Highest Weight.
		C. qr. lb.	C. qr. lb.	C. qr. lb.	C. qr. lb.
$\frac{3}{4}$	2	0 1 4	0 0 1	0 0 1	0 1 6
1	3	0 1 20	0 0 1	0 0 1	0 1 22
$1\frac{1}{2}$	6	0 3 13	0 0 2	0 0 2	0 3 17
2	9	1 1 6	0 0 4	0 0 4	1 1 14
$2\frac{1}{2}$	14	2 0 5	0 0 6	0 0 6	2 0 17
3	20	2 3 20	0 0 8	0 0 9	3 0 9
$3\frac{1}{2}$	26	3 3 7	0 0 11	0 0 11	4 0 1
4	35	5 0 14	0 0 14	0 0 16	5 1 16
$4\frac{1}{2}$	44	6 1 22	0 0 18	0 0 20	6 3 4
5	54	7 3 19	0 0 22	0 0 24	8 1 9
$5\frac{1}{2}$	65	9 2 2	0 0 27	0 1 1	10 0 2
6	77	11 1 3	0 1 4	0 1 7	11 3 14
$6\frac{1}{2}$	91	13 1 11	0 1 9	0 1 13	14 0 5

The sizes of cordage hereunto annexed, from $\frac{3}{4}$ to $3\frac{1}{2}$ inches in circumference, are termed, in the navy, contract coils; all above, *viz.* 4 to $6\frac{1}{2}$ inch, are called hawsers. The yarn for both coils and hawsers should be warped 195 fathoms long, and the ropes, when completed, are to be 130 fathoms long. A hawl of yarn, consisting of 336 threads, 195 fathoms long, should weigh from 16 cwt. 1 qr. 7 lb. to 16 cwt. 2 qr. 24 lb. and no more, tarred in the same proportion as cablets and cables.

All cordage delivered into his majesty's dock-yards undergo a trial, which is, by proving one strand out of each rope, each thread (or yarn) of which having a weight, weighing one-third of an cwt. made fast to it, which it should lift; but if a certain number of yarns (according to the size of each rope) should break in the trial, the rope is rejected, otherwise it is received.

Particular attention should be paid not to send any kind of cordage into his majesty's dock-yards above its highest weight, allowed according to contract, as, in such case, all above that weight will be a loss to the manufacturer; the receiving officer not being authorised to allow any more than is specified in the contract.

N. B. It is to be observed, that, in making cordage by contract for the use of his majesty's navy, his majesty finds his own hemp, the contractor tar and labour at a certain price *per* ton. All cables and cordage to be tarred with good Stockholm tar, without mixture of any other, except about one-third part, which may be of Russia tar.

A white thread, twisted the contrary way, (sometimes called the rogue's yarn,) is to be laid in all the strands of the cables and large cordage; and a twine in the small cordage for the king's mark, so as to be seen on the outside of the strands.

In any of the strands, there is to be no greater number of threads at the ends of the cables or cordage than in the middle.

The only parliamentary regulations, relative to the manufacture of cordage, are contained in the following act; "An act for more effectually preventing deceits in the manufacturing of cordage for shipping; and to prevent the illicit importation of foreign-made cordage." 25 Geo. III. c. 56.

In July 1799, a patent was granted to W. Chapman and E. W. Chapman, of Newcastle-upon-Tyne, for their improved method of making cords and ropes, twined and untwined, from the spinning of the yarn inclusive, to the finishing of the rope or cordage. This invention appears, by the specification, to include material improvements in the spinning of rope-yarn, and in the manufacturing of cordage. Rope-yarns are at present spun by men, at an expence of from half a crown to five shillings *per* day, according to the situation of the place, whether in the out-ports, or on the river Thames. Or it is wholly spun by machinery.

In the practice of the first method rope-walks are necessary, and the fibres of the hemp are drawn into the yarn of different lengths proportionate in a given degree to their position in the outside or inside of the yarn; accordingly, when this yarn is strained, and its diameter collapses, the inside fibres of hemp bear the greatest strain, and thus they break progressively from the inside.

In the spinning by a mill the fibres are all brought forward in a position parallel to each other, previously to their receiving their twist. They are consequently all of one length; and, when twisted, the outside fibres are most shortened by forming the same number of spirals round a greater axis than the interior, and thus they must consequently break the first, on the same principle that the outside yarns of strands of ropes manufactured in the old method break before the interior yarns; and, consequently, with less strain than ropes of the improved principle, where the strands, (or immediate component parts of the rope) have been formed in such a manner as that all the yarns shall bear equally at the time of the rope's breaking.

Nevertheless, yarns spun by a mill have been found stronger than common yarns, on account of the great evenness with which they are spun; the manual labour in manufacturing is much less than in the common method: but, on the other hand, there is the expence of machinery, and the greater waste of hemp in preparing it for being drawn out in the progressive stages of its advance to the spindle.

The method invented by Messrs. Chapman differs from both the preceding, in having, by an easy and simple contrivance, the fibres of the hemp laid in the yarn in such a manner as the yarns themselves are laid in the strands of the rope manufactured on the new principle.

Their machinery consists only of a spindle, divided into two parts, the upper containing apparatus to draw forward the hemp from the spinner with twist sufficient to combine the fibres; which enables them to employ women, children, and invalids, and also to appropriate the rope-ground solely to the purpose of laying ropes.

The part we have described is only an improvement on

the methods of spinning, granted to Mr. William Chapman on the 8th day of November, 1798.

The remaining parts of their invention consist chiefly in the giving, from a stationary power, internal motion to a locomotive machine, *viz.* to the roper's sledge, on which the strands and the rope itself are twisted, by which contrivance they are enabled to apply a water-wheel, or steam-engine, to the whole process of making ropes of all kinds whatever.

Mr. Joseph Huddart of Islington obtained a patent in August of the same year for an improved method of registering or forming the strands in the machinery for the manufacture of cordage. Having previously taken out a patent for this purpose, he contrived to effect it by the following means:

1. By keeping the yarns separate from each other, and drawing them from bobbins, which revolve, to keep up the twist whilst the strand is forming.

2. By passing them through a register, which divides them by circular shells of holes; the number in each shell being agreeable to the distance from the centre of the strand, and the angle which the yarns make with a line parallel to it, and which gives them a proper position to enter.

3. A cylindrical tube, which compresses the strand, and maintains a cylindrical figure to its surface.

4. A gauge to determine the angle which the yarns in the outside shell make with a line parallel to the centre of the strand when registering; and, according to the angle made by the yarns in this shell, the length of all the yarns in the strand will be determined.

5. By hardening up the strand, and thereby increasing the angle in the outside shell, which compensates for the stretching of the yarns, and the compression of the strand.

The patent which Mr. Huddart took out in August relates to the invention of a machine that may be worked by men, or any other power, and by means of which the registering may be commodiously and effectually carried on. But figures are necessary for describing intelligibly his peculiar contrivance. Mr. Huddart, in the following year, took out a patent for improvements in the method of turning cordage in the manufacture of it. But our limits forbid our enlarging on this article. The specifications of the patents for registering, as well as fastening, may be consulted by those who are concerned in this manufacture.

Rope *Walk*, or *Rope-house Ground*, is the place where ropes are manufactured. This should be 400 yards long, and about 10 broad. At the upper end are fixed the spinning-wheels, over which is the hatchelling-loft, also the back-frame wheels, tackle-boards, and posts, winches for winding the yarn on as it is spun, and reels on which to reel the ropes. On each side are stake-posts; in the middle is fixed the warping-post, and at the lower end, the capstern and reaching-post. Back-frame wheels for small, and sledges and drags for large ropes, are used towards the lower end; the back-frame wheel, for laying cordage from a six-thread ratline to a two-inch rope, is about four or five feet in diameter, and is hung between two uprights, fixed by tenons on a truck, and supported by a knee of wood. Over its top is a semicircular frame, called the head, to contain three whirls (that turns on the brasses) with iron spindles, secured by a hasp and pin. They are worked by means of a leather band encircling the whirls and the wheel. Three of the whirls are turned when hardening the strands, and one only when closing the rope, the strands being hung together upon it. The truck, on which the back-frame wheel is fixed, runs on four wheels, and is made of three-inch oak plank, about nine feet long and thirteen inches broad at one end, and eleven inches broad at the other. The capstern, about eight feet high, and fourteen inches in diameter, is turned either by men or horses; its use is to draw the yarn, when tarring, out of the copper, through the nipper, to be coiled away in the yarn-house, and there properly hardened before it is used; otherwise it will kink, *i. e.* twist or curl, by being twisted too hard in closing. Another capstern, or crab, is fixed at the lower end of the walk, for stretching the yarn to its fullest extent, before it is worked into strands, by means of the tackle-fall, led from the *sledge* to the capstern; these being about eighteen yards distant from each other. The crank-wheel, which is used for spinning of lines, box-cord, &c. is fixed on an iron spindle or axis, with a handle by which to turn it. It hangs between two posts, and in its upper part, above the wheel, is let in a semicircular board to receive three sets of whirl-bolts, with wheels upon them, on which the spinners hang their threads: at the front side of the wheel is a short post, supported by a knee of oak, on which the spindle rests. The *drags* resemble the hinder part of the sledge, to which they are fastened by ropes, and they are lined with a board on the upper side: their weight serves as a press, when the rope requires more than the sledge can carry properly to stretch the strands, and prevent their kinking. The *hatchel* serves to clear the ends of the hemp, by drawing it through, having forty sharp-pointed iron-teeth, similar to the hatchel in the *clearer*, which has finer teeth. Iron-jacks are sometimes used instead of the table-wheel or back-frame wheel, and differ from the latter by having an iron-wheel with cogs, which work in the whirls, that have likewise iron-cogs. The *loper*, which is used to lay lines, has two iron swivel-hooks (running round in a brass or iron box) at each end, for the line to hang on and work, by the power of the fore-turn, from the wheel at the upper end. The *nipper* is formed of two steel-plates, with a semi-oval hole in each, which, by the motion of the upper plate, enlarges or contracts as the tarring of the yarn requires. It is thus fixed: a post is placed between the kettle and the capstern, with a mortise cut eighteen inches long from the kettle's surface, and five inches wide. The under plate is turned up on each side, to form two grooves, and is let into the front side of the post from the lower part of the mortise. The upper plate has a dove-tail on the back, that slides up and down in a groove into the grooves of the lower plate; and by a staff, made fast to its front, it is raised or lowered, and regulated by a weight suspended at the other end, so that the yarn receives no more tar than is required, and that which is squeezed out drops into a trough, and returns into the kettle. *Press-barrels* are old tar-barrels filled with clay, and laid on the sledge or drag to add weight when the rope is closing. The *reaching-post* is a post in the ground at the lower end of the walk; used in stretching the yarn by means of a tackle, one of the blocks of which is hooked to a strap round the post, the other block to a pendant at the sledge, being about eighteen yards distant from each other. *Sledges* are frames made of strong oak, clamped with iron in different parts; the two sides are the length of the sledge, made of oak, and tied in with oak bars at each end; near the front are two uprights, let into the sides, and supported by two slanting pieces from the upper end. A breast-board is fastened with iron pins to the uprights, and contains holes for the hooks to pass through, on which the hooks are hung; which, being turned by men, is twisted into rope, and so closed or finished. These sledges are loaded as the occasion of making the rope requires. The *spinning-wheel* is hung between two posts

fixed in the ground; over its top is a semicircular frame, called the head, which contains twelve whirls, if it be for twelve spinners to spin at the same time; these whirls turn on iron spindles, with hooks to their front ends to hang the hemp on, and are worked by means of a leather band encircling the wheels and whirls. The tools and terms appropriate to rope-making are described in their proper places.

Rope-*Yarn*, the yarn of any rope untwisted. It commonly consists of cable-ends which are worn out; and are called *junks of the cables*. It serves for many purposes among the sailors.

Rope-yarn properly denotes the smallest and simplest part of any rope, being one of the threads of which a strand is composed; so that the size of the latter, and of the rope into which it is twisted, are determined by the number of rope-yarns.

Ropes, *Standing*, in a *Ship*, the shrouds and stays are so called, because they are not removed, unless to be cased or set taught. See Shrouds, and Stays.

Ropes, *Staple*, ropes made of hemp, not inferior to clean Petersburgh.

Rope-*Bands*, braided cordage, used to fasten the heads of sails to their respective yards. See Robbins.

Rope-*Deck*. See Deck.

Rope, in *Agriculture*, a thick sort of cord formed of hemp, or other material; much used by farmers. See Cordage.

A very useful sort of rope for traces, and other similar purposes, has lately been formed of the coarse wool of sheep.

Rope, *Cart*, that sort of rope used in loading hay, straw, or other bulky loads, by the farmer. These ropes should always be strong, and formed of the best materials, whatever the nature of them may be.

Rope is also a word signifying to tedder, as a horse, or other animal. It is a very injudicious practice, and one which should by no means be generally followed by farmers.

Rope, *Cord*, or *Strap*, in the *Manege*, is any of these tied round a pillar, to which the horse is fastened, when they begin to quicken, and supple, to teach him to fly from the chambrier, and not gallop fastly or incompactly.

In those maneges where there is no pillar, a man stands in the centre of the ground, and holds the end of the rope.

Ropes, *Drag*, in the *Artillery*, are those by which the soldiers pull the guns backwards and forwards both in their exercise, and in an engagement. They are of various lengths and dimensions, as they are used for guns or howitzers of different weights.

Ropes, *Foot*. See Foot-*Ropes*.

Ropes *of two Pillars*, are the ropes or reins of a caveson, used to a horse that works between two pillars. See Pillar.

Rope-*Dancer*. See Dancer, and Nusance.

Rope *of Sand*, a phrase familiarly used to denote disunion, or want of adhesion and continuity. In this sense it is applicable to a variety of cases, and in military language to the disagreement that subsists between the colonel and the captains of a regiment.

Rope *Machine for raising Water*, in *Hydraulics*.—If a vertical grooved wheel, fixed in a frame, be situated within the water at the bottom of a well, and another similar wheel, having a handle affixed to its axis, be situated in another frame at the upper part of the well; also an endless rope (*viz.* a rope whose two extremities are spliced into each other) be passed round both wheels; then, on turning the handle, the wheels and the rope will be caused to move, *viz.* the rope will ascend on one side, and will descend on the other, passing successively through the water of the well; but the ascending part will carry up a quantity of water adhering to its surface; and this water differs in quantity, according to the size of the rope, the depth of the well, and the quickness of the motion; *viz.* with a larger rope, in a less deep well and quickest motion, a greater quantity of water will be raised, than otherwise.

In order to intercept the water at the top of the well, the upper wheel is inclosed in a pretty large box, in the bottom of which there are two holes, through which the ascending and descending parts of the rope pass. To these holes are affixed two short tubes, which prevent the exit of the water which falls to the bottom of the box. There is also a lateral spout on the side of the box, close to the bottom, for the water to come out of; and on the broad sides of the box there are two holes for the axis of the wheel. The 9th and 10th figures of *Plate* XIV. *Hydraulics*, exhibit a section and a front view of a machine of this sort, which was put up in the year 1782, on the castle hill at Windsor, where the depth of the well is 95 feet. A similar machine was also placed on the round tower of Windsor castle, which draws the water from the depth of 178 feet.

The same letters refer to the like parts in both figures.

The wheel, H, at the bottom of the well is of lignum vitæ, one foot in diameter. Its axis is of steel, and turns with its extremities in sockets of bell-metal.

The frame, I I, is of iron.

The wheel, E E, at the top of the well is of iron; but its rim, with the groove which receives the rope, are of lead. The diameter of this wheel is three feet.

The axis, *d d*, is of steel, and its extremities turn in bell-metal sockets, which are fixed in two upright posts, A, A, that support the machine. T is the handle affixed to the axis, which handle describes a circle of 28 inches in diameter; *b b* is the wooden box, lined with lead, which incloses the wheel E. F, F, are the holes at the bottom of the box through which the rope passes. Their diameter is about two inches.

On the same axis, *d d*, another wheel, C C, of about four feet in diameter, is fixed. This wheel is of wood, loaded on the edge with lead, and it serves as a fly to facilitate the motion.

The rope is of horse-hair, and measures half an inch in diameter.

With this identical machine, several experiments were tried, the result of which is as follows:

When the machine was worked slowly, *viz.* so as to make about 30 revolutions of the handle in one minute, then very little water came up adhering to the rope; and of this water a very small portion was separated from the rope within the box, so as to come out of the spout Z, in the side of the box.

When the revolutions of the handle were about 50 in a minute, then a considerable quantity of water came up adhering to the rope; and on turning the wheel E E round, the greatest part of that water, having acquired a considerable velocity, flew off in a tangent from the rope, and formed a jet within the box. This water, falling to the bottom of the box, came out of the spout Z.

It was found, that the utmost exertion of an ordinary working man could not make more than 60 revolutions of the handle in a minute; in which case the rope moved at the rate of about 16 feet *per* second. With this velocity the quantity of water that came out of the spout, Z, was about six gallons *per* minute: but it would have been im-

possible for the man to have worked at that rate for more than three or four minutes.

This machine may evidently be placed aslant, *viz.* so as to convey the water from one place to another, which is not quite perpendicularly over the former. The same construction, and almost the same expence, will adapt the machine to wells of different depths, though the effects will not be always the same.

More than one rope, or a broad band instead of a rope, might be adapted to this machine, for which purpose, the wheels must have more than one (or a broad) groove, &c.

The greatest disadvantage of this machine is, that the rope does not last long. Its being always wet destroys it very soon. In putting on the rope, care must be had to soke it well in water before it be spliced; otherwise it will either be too tight, or it will break. A hair rope has been found to last longer than one of hemp. See Cavallo's Elem. of Nat. and Exp. Philosophy, vol. ii.

Rose engine

Rose *Engine*, *Rose lathe*, or *Figure lathe*, in the *Mechanic Arts*, is a machine used for turning any articles in wood, ivory, or metal, in the same manner as a common lathe, but it has additional parts, by which the surface of the subject which has been turned, can afterwards be engraved with a great variety of patterns of curved lines, which, in general, are denominated from the French *rosette*, from a slight general resemblance which they have to a full-blown rose, and hence the machine is called a rose engine.

This machine, as we have said, contains all the parts of the *lathe*, (see that article,) and in the same manner as in turning, the work is caused to revolve, whilst the cutting tool is kept stationary; but the difference between the rose

lathe and the common lathe is, that in the former the centre of the circle, in which the work revolves, is not a ſtationary point, but a ſlight motion is given to the centre whilſt the work is revolving upon it, the tool being all the while ſtationary; the ſurface of the figure which it forms will be, of courſe, out of round, *i. e.* it will deviate from the circular figure as much, and as often, as the motion is given to the centre.

The art of turning curioſities in wood or ivory, is one of thoſe which is beſt adapted, of any of the mechanic arts, as an amuſement for perſons who either have leiſure to apply to ſuch ſubjects, or who require relaxation from mental ſtudies: it has long been a favourite purſuit of many gentlemen, and the machines they employ are very ingeniouſly conſtructed. The curious in this art reckon two points of perfection in their works, one where the extreme delicacy, or elegance, of the object renders it admirable, and the other is conſidered from the difficulties of the execution; the former may be judged by all perſons poſſeſſed of good taſte, but to judge of the latter requires ſome knowledge of the art, or, at leaſt, ſo far as to know that the lathe will form only ſuch articles as are perfectly circular, all the parts having a common axis; therefore the ſpecimens of turning are to be more or leſs eſteemed, in proportion as they are more oppoſed to the circular figure. This art was more cultivated a hundred years ago than at preſent, and more curious ſpecimens were then produced, ſuch as hollow balls of ivory, containing many excentric figures, formed within each other, all being cut from the ſame ſolid piece, and every one beautifully ornamented upon the ſurface, although only ſmall holes were left through them to gain acceſs to the interior ones: this was carried ſo far as to form twelve balls of ivory one within the other. A great collection of curioſities of this kind will be found in a French work entitled "Récueil d'Ouvrages Curieux dans le Cabinet de M. Grollier de Servir," 4to. Lyons, 1719. This contains drawings of ſome very curious articles; but although the art is not ſo generally practiſed at the preſent day as formerly, the machines which are now invented are vaſtly ſuperior, and, with the ſame attention, would doubtleſs admit of the curioſities being equally extended. Meſſrs. Holtzapffel and Deyerlien, of Cockſpur-ſtreet, London, have made many improvements in the conſtruction of roſe engines, which they execute, as well as all other tools, for ornamental turning, in the moſt finiſhed ſtyle. We have obtained drawings of one of theſe, ſee *Plate* III. *Engines*, in which *fig.* 6. is an elevation in front of the machine. A A B B is the wooden frame; D, the large foot-wheel, to give motion to the mandrel, or ſpindle, T T, by the band and pulley F. The work is fixed in a chuck I, at the extremity of the mandrel; and the tool is held by the ſlide-reſt K, which, though it has the means of moving the tool a ſmall quantity, to adjuſt it to the radius of the roſe, or figure intended to be cut, ſtill it will firmly retain the poſition in which it is placed. The upper part, A, of the frame of the machine is made of mahogany, but has within it a caſt-iron frame, conſiſting of two bars, or bearers, which being placed parallel, and at a ſmall diſtance aſunder, leave a groove or opening between them, in the ſame manner as the cheeks of any other lathe, for the reception of the tenon, at the lower end of the back puppet (ſhewn by the dotted lines) L, which is uſed to ſupport the end of a long piece of work; though this is ſeldom uſed, becauſe the work can only be turned circular, when the back centre ſupports it. All work which is to be figure-turned muſt be held in a chuck, ſcrewed on to the end of the mandrel T; becauſe it is only the mandrel which is moveable, to give thoſe deviations from the circular figure, which are neceſſary to form the figured work. For this purpoſe, the two ſtandards, G and H, which ſupport the mandrel, are not firmly fixed to the bed, A, of the machine, as in other turning-lathes; but they deſcend between the cheeks or caſt-iron bed, almoſt as low as the bottom of the mahogany bed A, and have there an axis P (dotted), which is parallel to the mandrel, and ſupported on pivots at its ends; theſe pivots being received in pieces of caſt-iron, deſcending from the cheeks, and ſtrengthened by the iron bar, Q, extended between them. The two ſtandards, G, H, are formed of one piece, and have a ſtrong bracing of iron between them, in addition to the axis P; but this cannot be ſeen in the figure, becauſe it is concealed between the cheeks of the bed O. The oſcillating motion is given to the mandrel by means of metal roſettes M: theſe are wheels, fixed upon the mandrel, each having its periphery indented and curved with a waving line, as ſhewn at M, *fig.* 7. The roſettes are acted upon by a ſmall roller, placed at the end of a piece *n*, which is ſupported by a triangular bar *m*, fixed parallel to the mandrel, upon the upper ends of curved arms, as ſhewn in both figures. Now it is evident that when the mandrel revolves, the eminences and depreſſions of the roſette, applying themſelves to the roller of the piece *n*, which is ſtationary, will cauſe a vibrating or oſcillating motion of the mandrel, and the frame, G H, which contains it. A ſtrong ſpring is placed within the cavity of the bed A, and applied to the frame of the mandrel; ſo that it inclines the latter always towards the central or vertical poſition, that is, the poſition, when the line of the mandrel is produced, would paſs exactly through the point of the ſcrew of the back puppet L; therefore, when the protuberant or waved parts of the roſette cauſes the mandrel to depart from this ſituation, the ſpring will be bent, and ready to force it back, the inſtant the curvature of the roſette will permit. The ſpring is ſlightly curved, and placed in the ſpace between the inſides of the iron cheeks of the bed and the frame of the mandrel, ſo that the middle of the curved part acts thereupon, and the two ends bear againſt the inſide of the frame, to give the re-action. Seventeen different roſettes are placed upon the mandrel, as ſhewn in a cluſter at M, each being of a different pattern. Several are of the kind ſhewn in *fig.* 7, that is, ſcolloped out with waves or concave depreſſions, but differing in the number of waves from 12, as in the figure, to 144, which will, therefore, be very minute. The ſocket for the piece *n* can be fixed, by its clamp ſcrew, upon any part of the triangular bar *m*, to bring it oppoſite any one of the roſettes which is required to be uſed. Other roſettes, inſtead of having waves or concave depreſſions, as ſhewn in *fig.* 7, have convex protuberances. In either caſe, when the pattern is very fine, the roller upon the end of the bearing-piece, *n*, cannot be admitted, becauſe its curvature would not be ſufficiently rapid to ſuffer it to fall into the depreſſions. In theſe caſes, therefore, the end of the piece *n* is uſed for the contact, being rounded, and well hardened and poliſhed, to diminiſh as much as poſſible the friction of the roſette revolving, whilſt in contact with it.

The ſlide-reſt, which ſupports the tool, is next to be deſcribed: the manner in which it applies to a piece of work, when fixed in a chuck at the end of the mandrel, is ſhewn in *fig.* 6, whilſt *figs.* 11 and 12 are on a larger ſcale to deſcribe it minutely. The reſt can be faſtened at any part of the bed, by the lower part of the foot, which is ſupported on the bed, A, of the lathe, and is divided with a dove-tailed groove in the under ſide, to receive the head of a ſcrew-bolt, going down through the lathe-bed, and fixing it at any place by a thumb nut, as ſhewn at *k*, *fig.* 6; the groove in the foot is for the purpoſe of allowing the reſt to be moved to and from the

centre of the lathe, to adjuſt it to the diameter of the work which is turning. The foot has a ſtrong cylindrical pin fixed upright in the end of it, and this is fitted into a correſponding ſocket S, formed out of a ſolid piece, with the lower ſlider K of the reſt; a clamp-ſcrew in the ſide fixes the ſocket faſt upon the pin, and there is a wheel *s*, cut with notches, at the bottom of the ſocket, with a catch *t*, fixed upon the foot R, to engage its teeth and hold it faſt; by which means the ſliders, K, can be fixed, and held faſt at any required angle with the mandrel, for purpoſes we ſhall hereafter mention.

The upper part of the ſlide-reſt conſiſts of two horizontal ſliders, K and *g*, placed in directions perpendicular to each other; to one of theſe the tool is firmly attached, and by means of ſcrews with handles, the ſliders and the tool can be moved in any direction, to follow the tool to the work; K, in both figures, is a frame of metal, formed from the ſame piece as the ſocket S; its upper ſurface is made flat, and upon this a ſlider, or flat plate, *e e*, is fitted, to move with freedom and preciſion. A ſcrew is mounted in the opening of the frame, and is tapped into a piece of metal, projecting from the lower ſide of the ſlider, ſo that the ſcrew, when turned round by a handle *d*, fitted on its ſquare end, advances, or draws back the ſlider, which is guided in a right line by two pieces of braſs, ſcrewed to the under ſide of it, to form a dove-tailed groove, to which the edges of the frame K are fitted very accurately: upon this ſlider a frame, or two rulers, are ſcrewed, having a ſecond ſteel ſlider *g*, fitted in the dove-tailed groove formed between them, and provided with a ſcrew *i*, as the former, to move it. This upper ſlider carries a piece of metal, with a ſquare hole through it, in the direction of its length, to receive the tool *k*, and a ſcrew at top to faſten it in. The ſlide-reſt being mounted in the manner of *fig.* 6, upon the bed of the lathe, the upper ſlider, *g*, is parallel with the mandrel, and the lower one perpendicular thereto. For turning flat or face work, the tool is put as there ſhewn. Now, by turning the ſcrew, *i*, of the upper ſlider, the tool advances to a contact with the work, which is mounted in a chuck, as in the figure; then by the other ſcrew, *d*, it is moved acroſs the face of the work, turning it as it proceeds to a perfectly flat ſurface. For turning a cylinder, mounted between centers, the ſlide-reſt is to be turned one quarter round upon the pin in the ſocket S, ſo that the upper ſlider will be perpendicular to the mandrel, and the lower one parallel thereto; in this caſe, the upper ſlider muſt be moved, to adjuſt the tool to the diameter of the intended work, and the lower ſlider is moved by its handle *d*, to carry the tool along the length of the cylinder, and cut it as it goes. The whole reſt can be fixed at any part of the bed, and can be moved inſtantly if required. The ſlide-reſt will alſo turn cones by the following contrivance: the plate, or dove-tailed groove ſupporting the upper ſlider, *g*, may be turned round upon the plate *e e*, and faſtened at any inclination by a ſcrew paſſing through a circular groove in the plate. By this means, the upper ſlider is inclined, in any required angle, to the mandrel, and will then turn a cone, either hollow or ſolid. The ſlide-reſt preſents the tool ſo firmly to the work, that it will not retreat in the leaſt when any protuberance comes by, but cuts it away, if the ſtrain is not ſo great as to break the tool: but of this there is no danger if it be properly managed, becauſe the ſcrews advance the tool ſo ſlowly, that there is no need to puſh it forwards ſuddenly, as it is often unavoidable in turning by hand. The ſliders are often divided into inches and ſubdiviſions, by which the work can be made exactly to any dimenſions without trouble, or two things may be fitted exactly together. The upper ſlider, *g*, has a graduated arc to ſhew the angle of inclination which it makes with the lower one, when ſet for turning cones, ſo that a hollow cone being bored out in a chuck, a ſolid plug may at once be turned to fit it, without trial, the reſt making it certainly of the true angle.

The lathe is put in motion either by the hand, or by the foot of the turner. The latter, when the work is to be turned or reduced to the circular figure, as in any common lathe; and the former, when the work, after being turned, is to be ornamented, an operation which, from its delicacy, requires a very regular motion.

When the machine is turned by the foot, it is done by the preſſure upon the treadle E, which acts upon the crank C, on the axis of the foot-wheel, or fly-wheel, D. The motion is communicated from the treadle by a crank-hook, or connecting rod, *a*, faſtened to the crank of the wheel, by a collar embracing and turning round at the upper end. When the foot puſhes down the treadle, it gives the wheel a rotative motion; and when the crank has been drawn to the loweſt point, the momentum which the wheel has thus acquired, draws up the treadle, and thus, by the alternate preſſure of the foot, and the momentum of the wheel, the motion is regularly continued. The wheel is made of caſt iron, and fixed on the extreme end of the axis; it has two rims of different ſizes, and the ſurface of each is made conical, and cut with three annular grooves, which are receſſed, with an angle at the bottom, ſo as not to have a flat bottom. This form is advantageous, on account of the band having more power to turn the wheel F. Theſe different grooves are made, in order to give different degrees of velocity to the lathe, or to increaſe the power. The axle of the wheel is made of wrought-iron, except the pivots or centers, and it is bent in the middle to form the crank C: the pivots at the ends are made of hard ſteel, welded to the iron parts of the axle. The band which connects the fly and mandrel is made of catgut, of ſuch thickneſs as the nature of the work may require, and is either ſpliced at the joining of the two ends, or they are faſtened together by a ſteel hook and eye. The band may be either tightened, by ſhifting it to other grooves in the great wheel, or in the pulley F, of the mandrel; or otherwiſe by a ſliding-piece in the leg B, which is regulated by a ſcrew *x*.

The motion for the hand is given by a ſmall handle O, *fig.* 6; this is fixed upon the end of a ſpindle, which at the other end carries a ſmall wheel N, communicating by a band with the great wheel D. The ſpindle is ſupported in a frame, which is attached to the lathe-frame, by a centre or joint, on which it can be raiſed up, and fixed by a toothed ſector, to tighten the band when it is required.

The pulley F has three or four grooves, of different ſizes, to receive the band, and by this means the mandrel may be turned with different degrees of velocity, and made to accommodate itſelf to the length of the band. The wheel N is made in the ſame manner.

When a piece of work is to be made in the roſe engine, it is firſt turned true to the ſize and figure, and then poliſhed, before it is ornamented: therefore the machine is firſt ſet to turn circular. For this purpoſe, the piece *n*, *fig.* 7, is withdrawn, ſo as to be beyond the reach of the roſette, and a head at 2, *fig.* 6, being turned, it ſhoots a double bolt, which locks the frame G H faſt in its perpendicular poſition; that is, when the point of the back centre-ſcrew L will be exactly in the line of the mandrel, the frame being thus rendered immoveable, the machine will turn the ſame as any common lathe. If the work is of conſiderable length, it muſt be ſupported at the end by the back centre L, at leaſt whilſt it is turned circular, previous to being ornamented.

The back puppet, L, is made of caft-iron, and is fitted upon the caft-iron bearers, on which it can be fixed at the required diftance from the mandrel by a vertical fcrew underneath, and a nut, which comes in contact with a horizontal plate or wafher below the faid bearers. Its centre-fcrew has a fharp conical point to fupport the work, and there is a clamp-fcrew at top to faften the centre-fcrew, to prevent it from running back.

The methods of fixing the work to the end of the mandrel whilft it is turned are very numerous, and vary in almoft every inftance: in general, it is held in a piece of wood, I, called a chuck, which is fcrewed upon the nofe of the mandrel T, and being bored, or turned out in the manner of a cup, the piece of wood or ivory which is to be turned is driven into it by a mallet till it is firmly fixed: the wood is, of courfe, cut nearly to a circular figure, before it is fixed in the chuck; it is then wrought with a fharp triangular pointed tool, *b*, which being fixed in the reft, and advanced to the work by the fcrew *i*, cuts fmall contiguous grooves on the furface, till it has broken the grain of the wood, and removed all exuberances. The tool being gradually advanced by its fcrews *d* and *i*, as is required, the work is reduced at length nearly to its intended fize and figure, but will be wholly covered with fmall grooves: to remove thefe, and render the work even, another tool is next ufed; this is formed like a narrow chiffel, but made very thick, and with an obtufe edge, which is only bevelled on the under fide: its edge will remove the eminences between the grooves left by the firft tool. The work is then fmoothed, by applying to it the edge of a piece of the blade of a broken knife bevelled away; this is held in the hand, and the work is followed up with it, that its fharp edge may fcrape away any roughnefs left by the tools. To polifh the wood, a piece of feal-fkin, Dutch reed, or glafs paper, is held by the hand upon the work as it runs round, and it cuts away a fine powder, making the work fmooth enough to receive a polifh. This is raifed by firft applying a piece of bees-wax, till the work is flightly covered with it, then afterwards burnifhing or polifhing it, by holding a flat piece of hard wood upon it. The finifh can be given by the friction of a coarfe woollen rag, lightly fmeared with olive oil.

Ivory is turned nearly in the fame manner, but is polifhed with chalk and water, and afterwards by the friction of a woollen cloth; or, if it is firft touched with an oily rag, and rubbed off with a dry woollen cloth, it will have a very fine furface.

This is only the fame procefs as is ufed for ordinary turning; but when the work is finifhed in this manner, the ornamenting is began by releafing the bolt, 2, of the mandrel-frame G H, and chufing the rofette beft adapted to the pattern which is required. The piece, *n*, is fet upon the triangular bar, to be in contact with its wave, and will thus give the ofcillating motion, as before defcribed; fo that when the tool is applied to the work, it will produce a waved or indented furface, or outline, correfponding with the figure of the rofette, inftead of the circular figure produced by the common lathe.

If the ornamenting is to be performed upon a flat furface, fuch, for inftance, as the lid or top of a box, it is chucked, as fhewn in *fig*. 6, and the point of the tool being applied to it, will cut a waved line. To do this more conveniently, the flider, *g*, is advanced to the work, by preffing it with the hand inftead of the fcrew *i*; for, by lifting up a fmall fpring catch, of which the tail is feen plainly at 3, *fig*. 6, the flider is releafed from the nut of the fcrew *i*, which has no other attachment to the flider than by a tooth on this catch entering into a notch in the nut, and it is preffed into the notch by a fcrew *l*. Now, by releafing the fcrew *l*, lifting up the catch 3, and drawing back the flider, the tooth of the catch falls behind the nut of the fcrew, inftead of being in the notch; it will, therefore, form a ftop, to check the advance of the tool, though it allows it to be drawn back to clear the work, and alfo to be pufhed up towards it by the hand, to cut the line, the ftop regulating the depth of the line, as the hand can advance the flider no farther when it meets the nut.

In this manner, a waved line is engraved round the edge of it, fuch as is fhewn in *fig*. 9, the breadth of the line being determined by the depth to which the point of the tool is regulated to penetrate, by turning the fcrew *i*. The outer line being thus finifhed, the tool is now withdrawn to clear the work, and the fcrew, *d*, of the great flider being turned a fmall quantity, the point of the tool is brought nearer to the centre of the work; here, by pufhing up the tool, another line is defcribed; then a third within the fecond, and fo on, at equal diftances, until they reach the centre: this makes a very pretty ornament, as in *fig*. 9. It fhould be obferved, that as each line has the fame number of waves, or indentations, they will neceffarily grow very fine as they approach towards the centre; but at the fame time as the deviation from the circular figure is equal in the fmalleft as well as the largeft rings, it follows, that the curves of the waves of each ring, or line, will vary in a very gradual and pleafing manner, being flightly curved at the circumference, and more rapidly towards the centre. This pattern admits of great variety, by employing different rofettes, fine or coarfe, concave or convex; but it will always have the waves included in ftraight lines directed to the centre. A very pretty variation is made by turning the rofette round upon the mandrel a very fmall quantity every time before a frefh line is defcribed. For this purpofe, the rofettes are not fixed faft upon the mandrel, but are fitted thereupon, fo as to admit of turning round, being moved by a fmall fcrew at the end towards H. As an example of the ufe of this movement, *fig*. 10. is given, which confifts of a rofe of twenty-four waves. In this, after drawing the exterior line, in the fame manner as the former, when the flider is fet for the fecond, the rofette is turned round upon the mandrel a quantity equal to one-fourth of a wave, or one-ninety-fixth part of the whole circle: the circle is now defcribed, and its waves will not fall exactly within thofe of the former, but a little advanced therefrom. The next time a circle is to be drawn, the rofette is again fhifted, and fo on. As this is a quantity equal to one-fourth of the fpace between the waves, it is plain that at every fourth line the waves will fall in lines drawn towards the centre. Still this will not affect the appearance, which will be totally different from the former, (*fig*. 9.) and very fuperior to it. The concentric lines, in either of thefe patterns, are made exactly at equal diftances, by means of the divifions before-mentioned, upon the flider K, or otherwife by divifions made upon a head, which is fitted upon the end of the fcrew *d*; and the rofettes are fet exactly to the quantity they are intended to be turned round, by means of divifions made upon the edge of a circular plate, which is fixed faft upon the mandrel, towards the end H, and a line or mark upon the laft rofette applies to it. The fcrew which effects the movement is fupported in bearings upon this plate, and acts in the teeth of a wheel, fixed within the hollow of the laft rofette. By this means, when the fcrew is turned round by a key, it caufes all the rofettes to turn round together any quantity which the divifions on the circle indicate. On this principle, great varieties of patterns may be made, and they may be greatly diverfified by fhifting the rofettes alter-

nately in contrary directions: thus, after eight, twelve, or any other number of rings have been drawn, by gradually shifting them each time, as before described. By reversing the shifting movement to the opposite direction, a total change will be produced; and continuing in this manner for eight or twelve more circles, the rosettes are again to be advanced in the first-mentioned direction, and continued for eight or twelve. This method produces a curious effect, and admits of much variety in the patterns.

After, having drawn a waved line, the rosette may be advanced half a division, and then another line drawn, without altering the slide-rest. By this means, the two waved lines will intersect each other, and make a number of loops like a chain of beads. A number of concentric lines of this sort, drawn upon a circle, is very handsome.

We have now shewn the principal distinctions of the patterns which can be described upon a flat surface; but it is evident, that from the number of the rosettes, a very numerous suit of curious combinations can be made. An elliptical and an excentric chuck are adapted to this machine, to screw on at T: a new field is thus opened, which is so extensive as to exercise constantly the taste and fancy of the operator, in producing new combinations, and renders the machine a source of the most interesting amusement. The elliptical and excentric chucks, when applied to a common lathe, will form a great many interesting patterns, but are vastly more extensive with the rose engine. Their construction will be described under TURNING. It is sufficient here to say, that by the elliptical chuck, the waved lines may be drawn in ellipses, instead of circles; and by the excentric, several small waved circles, or ellipses, can be arranged round the circumference of a larger circle, and their intersections produce a very pretty effect.

Another species of rose-turning is performed upon the surface of a cylinder, globe, or cone; whereas that which we have described is only upon the flat surface of a circular piece, or end of the cylinder. To ornament the surface of the cylinder, the slide-rest is turned round one-fourth of a circle, as before described, for forming the cylinder; so that the long slider becomes parallel to the mandrel. In this way the whole surface of the cylinder may be waved; but great care must be taken to advance the tool very gradually, because it will not cut so readily as when turning circular work. By dividing the length of the cylinder into small equal portions, and by shifting the rosettes every time one of these is finished, the waves may be made to follow each other in a spiral direction round the cylinder; or, by a proper rosette used in this manner, very elegant patterns of basket-work may be formed.

There is another movement of the rose lathe, which we have not yet described: this is called the pumping. It is principally used for describing waved lines upon the surface of a cylinder; that is, the surface is left cylindrical, but the lines are waved in the direction of the length of the cylinder, or alternately towards its ends. This is effected by making the mandrel move end-ways in its bearings: for which purpose, the necks upon which it turns are made exactly cylindrical, and fitted very correctly to steel collars, which are fixed into the standards, G, H. It has, therefore, liberty to slide end-ways in its collars, when the pumping motion is required. This is given by rosettes waved upon the edge or side, and acting against the side of a piece of steel, such as *n*, *fig*. 7. A spring, *p*, *fig*. 6, is fixed at the end of the frame, and acts against the shoulder of the mandrel, to force it end-ways, and keep the rosette always in contact with the piece of steel. The rosettes, M, are cut in a waved manner upon their sides, as well as upon their circumferences; and thus a variety of pumping rosettes are obtained. By this means, curious waving lines may be drawn round a cylinder; or, if the motions first described are used in combination with the pumping, the surface of the cylinder may be waved, at the same time that waved lines are drawn upon it. In this case, the two rosettes employed must have the same number of waves. When the pumping motion is used upon face or flat work, such as is shewn in *fig*. 6, it produces very agreeable effects, by rendering the waves of the line, which the tool cuts, alternately deeper and shallower, so as to give fine and strong strokes alternately, in the manner of fine writing: or, if the tool is not set so deep, they will only be cut on one side of the wave, and diminishing gradually, will not be seen on the other, and thus produce a number of new patterns; as the waved lines will consist of detached strokes, cut fine at each end, and deep in the middle.

Many patterns may be cut very expeditiously in the rose engine by means of screw tools: these tools are formed like a broad chissel, but the edge is cut with notches, so as to present a number of points instead of one continued edge. These points are very exactly equidistant, being intended to cut screws; and therefore the teeth are of the proper figure to form the threads thereof. By a tool of this kind six or eight lines may be cut at one operation, instead of the trouble of altering the slide-rest, and cutting each separately; and there will be a greater certainty of cutting them all to the same depth, and exactly equidistant. The mode of cutting screws by this tool is called cutting flying, and is thus performed in the rose, or in any common lathe, without a slide-rest. The intended screw being turned cylindrical, the points of the tool are applied to its surface, so that they will cut, and the tool is regularly advanced up towards the mandrel as it turns round: its teeth will, therefore, instead of describing circles, trace the spirals of a screw on the work; and if the advancement is timed so exactly that in one revolution the tool is advanced the exact quantity of a space between two adjacent teeth, then the second tooth will, at the end of a revolution, fall into the spiral cut by the first tooth, and one complete spiral being thus obtained, it guides the whole tool, by means of the second tooth, regularly along, the first tooth continuing to cut the spiral forwards till a third tooth lays hold, then a fourth, and so on, till the required length of a screw is cut. The trace of a screw being thus made, the tool is pressed deeper, till the threads are fully formed, the turner taking care, every time, that the end-tooth of the tool gets to the end of the screw, to disengage it, and draw it back, for as it could not advance any further than the shoulder, it would spoil all the threads by cutting them to circular rings.

This method requires great habit and dexterity to give the motion so exactly that it will cause the teeth to fall properly into the spirals cut by their predecessors, and that without any sudden advance at the place, for the screw would then be what is called drunken, that is, its threads would be more inclined at one part of its revolution than at another, and such a screw can never be fitted exactly with its fellow. The habit of cutting screws accurately with the screw-tool, can only be acquired by practice and experience, the only precaution which is taken being to get the lathe-wheel into a regular motion, and at such a rate as has been found, by experience, will be proper for the size of the thread intended to be cut. The rose engine before us has a very complete apparatus for cutting screws, which deserves a particular description. A tube is fitted on the end of the mandrel at *o*, its circumference being cut with a spiral, or screw-thread of the degree of fineness required: this is called the regulator screw.

H is a flider, fitted to the ftandard H, and moved by a fcrew: r is a wheel fixed to this flider, and having feveral half-circle cavities cut in it, which embrace the fcrew, as fhewn in *fig.* 10: each cavity or focket has a thread in it, correfponding with the regulator fcrew. The mandrel being made, as before-mentioned, with cylindrical collars at each end, is at liberty to flide endways by the movement of the regulator, when the fcrew H draws up the focket r; therefore, every thing being prepared for cutting the thread, the fcrew H is turned; this raifes up the flider, and focket r, to touch the regulator; the tool is then applied by the flide-reft, and the lathe being put in motion, the mandrel will move along endways, and alfo the work with it, fo that the tool will cut a fcrew, although it is held faft by the reft. In this cafe the fcrew may be cut by a fingle pointed tool, but it will be better to ufe a fcrew tool which is of exactly the fame thread as the regulator. The turner fhould be provided with a variety of fets of fcrew tools, and as many regulators, o, correfponding to them, which are made like a tube, and fitted on the mandrel, being held by a nut. The focket r, which is made like a wheel, *fig.* 10, can be turned round on its centre, and has fix different half-circle notches cut in it, each adapted to a particular regulator; therefore, by turning this wheel, r, any of the notches can be applied to the regulator o, when the flider is raifed up by the fcrew H. This fcrew regulator may be fometimes ufed to advantage when ornamenting the circumference of a cylinder of wood or ivory, as contiguous circles, or waved lines, may then be cut in a fpiral direction, without moving the flide-reft to cut each one feparately.

Another part of the rofe engine is for the purpofe of turning fwafh work; this is circular work, but the mouldings or other lines traced round the cylinder are inclined to the axis. An inftance is feen in the baluftrades of old-fafhioned ftair-cafes, where the mouldings are made to fuit the inclination of the ftairs. To turn this kind of work, a fteel circle, or hoop, V, is fitted on the end rofette of the mandrel, fo that it can be inclined from the perpendicular thereto at pleafure: by this means it forms a guide for the pumping motion, which will fo regulate it as to turn any work of this kind, *viz.* with the mouldings, or other ornaments, arranged in lines round the cylinder, but thefe lines will incline to the axis of the cylinder inftead of being perpendicular to it.

Rotherham

ROTHERAM, in *Geography*, a market-town and parifh in the upper divifion of the wapentake of Strafford and Tickhill, Weft-Riding of Yorkfhire, England, is fituated near the confluence of the rivers Rother and Don, at the diftance of 45 miles S. by W. from the city of York, and 160 miles N.N.W. from London. It is defcribed by Leland as "a meatly large town, with a fare collegiate chirch," which was founded by Thomas Scott, archbifhop of York, and a native of Rotheram, in 1481, for a provoft, five priefts, a fchool-mafter in fong, and fix chorifters, alfo a fchool-mafter in grammar, and another in writing. This eftablifhment was diffolved by king Henry VIII. Camden calls Rotheram "a large footy market town," and not unaptly, for even at the prefent day it is far from meriting the appellation of handfome or agreeable. The ftreets are narrow and irregular; and the houfes, which are moftly conftructed of ftone, have a dull and dingy appearance. A confiderable trade in coals and other articles is carried on here, by means of the river Don. The market day for corn, cattle, and butcher's meat is on Monday, weekly; and on every alternate Monday is a fair for fat cattle, fheep, and pigs; there are alfo two annual fairs, on Whit Monday, and the firft day of December. Both markets and fairs are well attended; indeed Rotheram is one of the two greateft marts in Yorkfhire for fat cattle and fheep. The chief public buildings are the town-hall, the parifh-church, and two meeting-houfes, one for Independents and another for Methodifts. The church, according to Burton, in his "Monafticon Eboracenfe," was erected in the reign of Edward IV. It is a handfome and fpacious edifice, in the early pointed ftyle, and confifts of a nave, with two fide aifles, a chancel, and a tower at the weft end. Annexed to the church is a fchool-houfe, for the education of thirty poor children of the parifh of Rotheram. The clergyman for the time is governor, and has the nomination of the children; but the truftees of the founder, Thomas Hollis, of London, efq. appoint the mafter. This inftitution is managed under very excellent regulations, a copy of which is delivered to the parents of all children admitted to its benefits. In this town is likewife an academical inftitution, or college, for the education of Proteftant diffenters. It is called "The Rotheram Independent Academy," becaufe more immediately connected with the clafs of religionifts called Independents. It was firft opened in November, 1795, under the fuperintendance of the Rev. Dr. Williams, who prefided as divinity tutor, and is defigned for the education of young men propofing to become Independent clergymen. This academy is fupported by voluntary contributions. The building appropriated to it was erected by the late Samuel Walker, efq. and is calculated for the convenient accommodation of fixteen ftudents. The library contains above 1200 volumes, chiefly prefented by patrons of the inftitution; and there is likewife a tolerable collection of philofophical apparatus. The term of ftudy is four years, but the managers have a difcretionary power to prolong it if they think proper.

According to the parliamentary returns of 1811, the town of Rotheram alone contained 731 houfes, and 2950 inhabitants; and the reft of the parifh, including the town-

ſhips of Brinſworth, Catliffe, Dalton, Orgreave, and Tinſley, 209 houſes, and 986 inhabitants.

On the oppoſite ſide of the river from Rotheram is the townſhip, or village, of Maxborough, where very extenſive iron-works are carried on by Meſſrs. Walker. At theſe works cannon of the largeſt calibre are manufactured, as are alſo almoſt every kind of caſt-iron articles, with many of wrought-iron, ſuch as bar, ſheet, ſlit, or rod iron. Tin plates, and ſteel of every deſcription, are likewiſe made here in great quantities; and the iron bridges at Sunderland and Yarm were caſt at theſe founderies. The coal, and the iron-ſtone for the blaſt-furnaces, are chiefly ſupplied from the mines on the eſtates of the earl of Effingham, and thoſe of earl Fitzwilliam. Theſe works were commenced, in 1746, by Mr. Samuel Walker, and his brothers Aaron and Jonathan, and have ever ſince been progreſſively increaſing in extent and importance. In the Methodiſt meeting-houſe is a monument in memory of Mr. S. Walker; the epitaph was compoſed by the celebrated poet, the Rev. William Maſon, who was one of his moſt intimate friends.

The environs of Rotheram are agreeable and pictureſque. On an eminence to the eaſtward of the town ſtands an elegant manſion, belonging to the Walker family, which, in point of ſituation, can ſcarcely be excelled. Aldwark-Hall, the ſeat of J. S. Foljambe, eſq. ſituated at the diſtance of four miles from Rotheram, is alſo remarkable for its fine ſituation. Near it is the village of Wickerſley, noted for its manufacture of grindſtones, of which about 5000, of various ſizes, are ſtated to be formed annually, and ſent to Sheffield. The other principal ſeats in the neighbourhood of Rotheram, beſides thoſe mentioned, are Thundercliffe Grange, the ſeat of the earl of Effingham, and Wentworth Houſe, the princely reſidence of earl Fitzwilliam. The latter houſe conſiſts of a centre and two wings, extending about 600 feet in length. Many of the apartments are moſt ſuperb, eſpecially the hall and gallery, the latter of which is ſupported by beautiful Ionic columns, having intervening niches filled with marble ſtatues. Here, and in other parts of the houſe, are likewiſe many paintings; and among others the famous picture of lord Strafford and his ſecretary. Some fine antiques are preſerved in a room called the muſeum. Wentwork-park compriſes upwards of 1500 acres of ground, beautifully diverſified with wood, water, and lawn, and is enriched by ſeveral ornamental buildings. Among theſe is a moſt magnificent mauſoleum, erected by the preſent earl Fitzwilliam, in honour of his uncle, the late marquis of Rockingham. It is conſtructed of a very fine free-ſtone, and conſiſts of three diviſions; the firſt is a ſquare Doric baſement; the ſecond of the ſame form, but of the Ionic order; and the third preſents a cupola, ſupported by twelve columns of the ſame character. Within is an apartment riſing into a dome, which reſts upon eight pillars, encircling a white marble ſtatue of the marquis in his robes of ſtate, executed by Mr. Nollekens. Beauties of England and Wales, vol. xvi. by J. Bigland.

Rum

RUM, a ſpecies of vinous ſpirit, drawn by diſtillation from ſugar-canes. The word rum is the name it bears among the native Americans.

Rum is very hot and inflammable, and is in the fame ufe among the natives of the fugar-countries, as brandy among the French.

Rum differs from what we fimply call fugar-fpirit, in that it contains more of the natural flavour or effential oil of the fugar-cane; a great deal of raw juice, and parts of the cane itfelf, being often fermented in the liquor, or folution of which the rum is prepared.

The unctuous or oily flavour of rum is often fuppofed to proceed from the large quantity of fat ufed in boiling the fugar; which fat, indeed, of courfe, will ufually give a ftinking flavour to the fpirit in our diftillation of the fugar liquor, or wafh, from our refining fugar-houfes; but this is nothing like the flavour of the rum, which is really the effect of the natural flavour of the cane. The method of making rum is this:

When a fufficient ftock of the materials is got together, they add water to them, and ferment them in the common method, though the fermentation is always carried on very flowly at firft; becaufe at the beginning of the feafon for making rum in the iflands, they want yeaft, or fome other ferment, to make it work; but by degrees, after this, they procure a fufficient quantity of the ferment, which rifes up as a head to the liquor in the operation, and thus they are able afterwards to ferment and make their rum with a great deal of expedition, and in large quantities.

When the wafh is fully fermented, or to a due degree of acidity, the diftillation is carried on in the common way, and the fpirit is made up proof; though fometimes it is reduced to a much greater ftrength, nearly approaching to that of alcohol or fpirit of wine, and is then called double-diftilled rum. It might be eafy to rectify the fpirit, and bring it to much greater purity than we ufually find it to be of; for it brings over in the diftillation a very large quantity of the oil; and this is often fo difagreeable, that the rum muft be fuffered to lie by a long time to mellow before it can be ufed; whereas, if well rectified, it would grow mellow much fooner, and would have a much lefs potent flavour.

The beft ftate to keep rum in, both for exportation and other ufes, is doubtlefs that of alcohol, or rectified fpirit. In this manner it would be tranfparent in one-half the bulk it ufually is, and might be let down to the common proof ftrength with water when neceffary. For the common ufe of making punch, it would likewife ferve much better in the ftate of alcohol; as the tafte would be cleaner, and the ftrength might always be regulated to a much greater exactnefs than in the ordinary way.

The only ufe to which it would not ferve fo well in this ftate, would be the common practice of adulteration among our diftillers; for when they want to mix a large portion of cheaper fpirit with the rum, their bufinefs is to have it of the proof ftrength, and as full of the flavouring-oil as they can, that it may drown the flavour of the fpirits they mix with it, and extend its own. If the bufinefs of rectifying rum was more nicely managed, it feems a very practicable fcheme to throw out fo much of the oil, as to have it in the fine light ftate of a clear fpirit, but lightly impregnated with it; in this cafe it would very nearly refemble arrac, as is proved by the mixing a very fmall quantity of it with the taftelefs fpirit, in which cafe the whole bears a very near refemblance to arrac in flavour.

Rum is ufually very much adulterated in England; fome are fo barefaced as to do it with malt-fpirit; but when it is done with melaffes-fpirit, the taftes of both are fo nearly allied, that it is not eafily difcovered. The beft method of judging of it is by fetting fire to a little of it; and, when it has burnt away all the inflammable part, examining the phlegm both by the tafte and fmell. Shaw's Effay on Diftillery.

Mr. B. Edwards, in his "Hiftory of the Weft Indies," vol. ii. has given the following account of the procefs for extracting rum from the fugar-cane, or from the very dregs and feculencies of the plant, by fermentation and diftillation. He commences his account with obferving, that the ftill-houfes on the fugar-plantations in the Britifh Weft Indies, vary greatly in point of fize and expence, according to the fancy of the proprietor, or the magnitude of the property. In general, however, they are built in a fubftantial manner of ftone, and are commonly equal to the boiling and curing-houfes together. (See SUGAR.) For a plantation making, *communibus annis*, 200 hogfheads of fugar of 1600 weight, our author conceives, that two copper ftills, the one of 1200, and the other of 600 gallons, wine meafure, with proportionate pewter worms, are fufficient. The fize of the tanks (or tubs) for containing the cold water in which the worms are immerfed, muft depend upon circumftances; if the advantage can be obtained of a running ftream, the water may be kept abundantly cool in a veffel barely large enough to contain the worm. If the plantation has no other dependance than pond-water, a ftone tank is much fuperior to a tub, as being longer in heating, and if it can be made to contain from twenty to thirty-thoufand gallons, the worms of both the ftills may be placed in the fame body of water, and kept cool enough for condenfing the fpirit, by occafional fupplies of frefh water.

For working thefe ftills and worms, it is neceffary to provide, firft, a dunder-ciftern, of at leaft three thoufand gallons; fecondly, a ciftern for the fcummings; and laftly, twelve fermenting vats, or cifterns, each of them of the contents of the largeft ftill, *viz.* 1200 gallons. In Jamaica, cifterns are made of plank, fixed in clay; and are univerfally preferred to vats or moveable veffels, for the purpofe of fermenting. They are not fo eafily affected by the changes of the weather, nor fo liable to leak as vats, and they laft much longer. But in the Britifh diftilleries, fermenting cifterns, it is faid, are unknown. To complete the apparatus, it is neceffary to add two or more copper pumps for conveying the liquor from the cifterns, and pumping up the dunder, and alfo butts or other veffels for fecuring the fpirit when obtained; and it is ufual to build a rum-ftore adjoining the ftill-houfe.

The ingredients or materials for the procefs confift of melaffes, or treacle drained from the fugar; fcummings of the hot cane-juice, from the boiling-houfe, or fometimes raw-cane liquor, from canes expreffed for the purpofe: lees, or, as it is called in Jamaica, "dunder," from the Spanifh *redunder*, the fame as *redundans* in Latin; and water. Dunder, in the making of rum, ferves the purpofe of yeaft in the fermentation of flour. It is the lees or feculencies of former diftillations; and fome planters preferve it for ufe from one crop to another; but this is faid to be a bad practice. Some fermented liquor, compofed of fweets and water alone, ought to be diftilled in the firft inftance, that frefh dunder may be obtained. This is a diffolvent menftruum, and occafions the fweets with which it is combined, whether melaffes or fcummings, to yield a far greater proportion of fpirit than can be obtained without its affiftance. The water which is added acts in fome degree in the fame manner by dilution

In the Windward iflands, the procefs, we are told, is conducted as follows: the ingredients, *viz.* fcummings, one-third; lees or dunder, one-third, and one-third of water, are well mixed in the fermenting cifterns, and when they are pretty cool, the fermentation will rife, in twenty-four hours,

to a proper height for admitting the firſt charge of melaſſes, of which ſix gallons for every hundred gallons of the fermenting liquor, is the general proportion to be given at twice; *viz.* three *per cent.* at the firſt charge, and the other ſeven *per cent.* a day or two afterwards, when the liquor is in a high ſtate of fermentation; the heat of which, however, ſhould not, in general, be ſuffered to exceed from 90° to 94° Fahrenheit. The infuſion of hot water will raiſe, and of cold water abate the fermentation. The quantity of melaſſes above-mentioned, added to a third of ſcummings, gives 11½ *per cent.* of ſweets, ſix gallons of ſcummings being reckoned equal to one gallon of melaſſes. When the fermentation falls by eaſy degrees from the fifth to the ſeventh or eighth day, ſo as then to become fine, and throw up ſlowly a few clear beads or air-globules, it is ripe for diſtillation; though when the liquor is firſt ſet at the beginning of the crop (the houſe being cold, and the ciſterns not ſaturated) it will not be fit for diſtillation under ten or twelve days. When this is the caſe, at a longer or ſhorter period, the liquor or waſh being conveyed into the largeſt ſtill, which muſt not be filled higher than within eight or ten inches of the brim, leſt the head ſhould fly, a ſteady and regular fire muſt be kept up until it boils, after which a little fuel will ſerve. In about two hours the vapour or ſpirit, being condenſed by the ambient fluid, will force its way through the worm in the ſhape of a ſtream, as clear and tranſparent as cryſtal, and it is ſuffered to run until it is no longer inflammable. The ſpirit thus obtained is known by the appellation of "low wines." To make it rum of the Jamaica proof, it undergoes a ſecond diſtillation. Between the practice of the Jamaica diſtillers, and that of thoſe of the Windward iſlands, there is ſome little variation in the firſt proceſs. This conſiſts chiefly in the more copious uſe of dunder. As dunder ſerves to diſſolve the tenacity of the ſaccharine matter, it ſhould be proportioned, not only to the *quantity*, but alſo to the *nature* of the ſweets. If the ſweets in the fermenting ciſtern conſiſt of melaſſes alone, which is generally the caſe after the buſineſs of ſugar-boiling is finiſhed, when no ſcummings are to be had, a greater proportion of dunder is neceſſary; becauſe melaſſes are a body of greater tenacity than cane-liquor, and are rendered ſo viſcous and indurated by the action of fire, as to be unfit for fermentation without the moſt powerful ſaline and acid ſtimulators. For the ſame reaſon, at the beginning of the crop, when no melaſſes can be had, and the ſweets conſiſt of cane-juice or ſcummings alone, very little dunder is neceſſary. In ſuch caſe twenty *per cent.* at the utmoſt will be ſufficient. Dunder, in a large quantity, injures the *flavour*, though it may increaſe the *quantity* of the ſpirit. Dr. Shaw ſays, that the Engliſh diſtillers add many things to the fermenting liquor or waſh, in order to augment the vinoſity of the ſpirit, or to give it a particular flavour. He obſerves, that a little tartar, nitre, or common ſalt, is ſometimes thrown in at the beginning of the operation, or in their ſtead a little of the vegetable or finer mineral acid. Theſe are thought to be of great uſe in the fermenting of ſolutions of treacle, honey, and ſimilar ſweet and rich vegetable juices, which contain a ſmall proportion of acid. A ſimilar practice is ſaid to prevail among the diſtillers in St. Chriſtopher's, ſome of which conſider an addition of ſea-water to the fermenting liquor as a real and great improvement. Shaw recommends the juice of Seville oranges, lemons, and tamarinds, or other very acid fruits, and, above all other things, an aqueous ſolution of tartar; but Mr. Edwards is of opinion, that dunder alone anſwers every purpoſe. Dr. Shaw alſo recommends to the diſtiller to introduce into the fermenting ciſtern a few gallons of the rectified ſpirit, which, he ſays, will revert, with a large addition, to the quantity of ſpirit that would otherwiſe have ariſen from the diſtillation. It is ſuggeſted by Mr. Edwards, that a ſmall quantity of vegetable aſhes, thrown into the rum-ſtill, will be found ſerviceable. The alkaline ſalts are ſuppoſed to attenuate the ſpirit, and keep back the groſs and fetid oil, which the diſtillers call the "faints," but if too freely uſed, they will alſo keep back a proportion of the fine eſſential oil, on which the flavour of the rum wholly depends. After all, the moſt important object of attention in making good rum is probably "cleanlineſs;" for all adventitious or foreign ſubſtances deſtroy or change the peculiar flavour of the ſpirit. It ſhould, indeed, be an invariable practice with the manager or diſtiller to take care that the ciſterns are ſcalded, and even cleanſed with ſtrong lime-water, every time when they are uſed; not merely on account of the rum, but becauſe it has often happened that the vapour of a foul ciſtern has inſtantly killed the firſt perſon that has entered it without due precaution.

The following improved method of conducting the proceſs, or of compounding the ſeveral ingredients, is very general in Jamaica, *viz.*

Dunder one half, or		50 gallons	
Sweets 12 *per cent.* -	Melaſſes -	6 gallons	42 gallons.
	Scummings	36 gallons (equal to ſix gallons more of melaſſes)	
Water - -		8 gallons	
		100	

Of this mixture, or "waſh," as it is ſometimes called, 1200 gallons ought to produce 300 gallons of low-wines; and the ſtill may be twice charged or drawn off in one day. The method of adding all the melaſſes at once, which is done ſoon after the fermentation commences, renders the proceſs ſafe and expeditious; whereas by charging the melaſſes at different times, the fermentation is checked, and the proceſs delayed.

The low-wines obtained in the manner above deſcribed, are drawn off into a butt or veſſel, and, as opportunity ſerves, are conveyed into the ſecond ſtill of 600 gallons, to undergo a further diſtillation. The ſteam begins to run in about an hour and a half, and will give, in the courſe of the day, 220 gallons, or two puncheons, of oil-proof rum, *i. e.* of ſpirit in which olive oil will ſink; and thus the manufacture, if ſo it may be called, is complete. There will remain in the ſtill a conſiderable quantity of weaker ſpirit, commonly about 70 gallons, which is returned to the low-wine butt. Thus 220 gallons of proof-rum are made, in fact, from 530 gallons of low-wines, or about 113 of rum from 1200 of waſh. By this proceſs the Jamaica diſtiller may fill weekly, working only by day-light (a neceſſary precaution in this employment), and at a ſmall expence of labour and fuel, twelve puncheons of rum, containing each 110 gallons of the Jamaica ſtandard. The proportion of the whole rum to the crop of ſugar, is commonly eſtimated

in Jamaica as three to four. Thus a plantation, ſuch as we have above deſcribed, is ſuppoſed to ſupply annually 150 puncheons of rum of 110 gallons each, or 82 gallons of Jamaica proof to each hogſhead of ſugar; and this quantity is ſometimes fairly made from canes planted in rich and moiſt lands; but on a general eſtimate, Mr. Edwards thinks this to be too great an allowance; and that 200 gallons of rum to three hogſheads of ſugar, which is in the proportion of about two-thirds rum to the crop of ſugar, is nearer the truth. The following ſtatement warrants the above concluſion. The general ſupply of ſcummings to the liquor-houſe is ſeven gallons out of every 100 gallons of cane-liquor. Suppoſing, therefore, that 2000 gallons of cane-juice are required for each hogſhead of ſugar of 16 cwt., the ſcummings, on a plantation making 200 hogſheads *per annum*, will be 28,000 gallons, equal to 4666 gallons of melaſſes.

lons, equal to	4666 gallons of melaſſes.
Add the melaſſes from the curing-houſe, which, if the ſugar is of a good quality, will ſeldom exceed 60 gallons *per* hogſhead	12,000
Total of ſweets	16,666 gallons.

This quantity, diſtilled at or after the rate of 12 *per cent.* ſweets in the fermenting ciſtern, will give 34,720 gallons of low-wines, which ought to produce 14,412 gallons of good proof rum, or 131 puncheons of 110 gallons each. When a greater proportion than this is made, either the ſugar diſcharges an unuſual quantity of melaſſes, or the boiling-houſe is defrauded of the cane-liquor by improper ſcumming; which latter circumſtance frequently happens.

It is the practice of late, we are told, with many planters, to raiſe the proof of rum: thus gaining in ſtrength of ſpirit what is loſt in quantity: and ſome managers make it a rule to return the ſcummings to the clarifiers, inſtead of ſending them to the ſtill-houſe. This laſt-mentioned practice reduces the crop of rum more than one-third; but is ſuppoſed to yield in ſugar more than is loſt in rum: and if the price of ſugar is very high, and that of rum very low, it may be prudent to adopt this method.

For the duty, &c. on rum, ſee *Foreign* SPIRITS.

RUM, in *Geography*, a town of Tonquin, on the coaſt. N. lat. 19° 35'. E. long. 105° 18'.—Alſo, a river of America, which runs into the Miſſiſippi, N. lat. 45°. W. long. 93° 48'.

RUM, one of the Hebrides, or Weſtern iſlands of Scotland, is ſituated to the weſtward of the iſle of Skye, and is compriſed, politically, in the pariſh of Small-Iſles, and in the county of Argyle. It derived its name from the Gaelic, *Rhum*, ſignifying extent, in alluſion to its being the largeſt iſland in the pariſh to which it belongs. It is computed to meaſure eight miles in length, and nearly the ſame in breadth; and to contain about 22,000 ſquare acres. Rum is in general rugged, mountainous, and barren, and more adapted for paſturage than for agriculture. Horſes are reared in this iſland for ſale, and though diminutive in ſize, are remarkably high mettled and hardy. Here are likewiſe reared a conſiderable number of ſheep, which are the beſt ſtock with which a mountainous country, like Rum, can be ſupplied. The general breed is a ſmall white-faced ſheep, which is much praiſed, both for the delicate flavour of its fleſh, and for the excellence of its wool. This iſland formerly abounded with deer; but that animal is now totally extirpated, owing to the copſe wood, which ſerved as a cover to their fawn, having been deſtroyed. Before the uſe of fire-arms, the method adopted by the inhabitants to kill deer was ſo ſingular as to deſerve notice. On each ſide of a glen formed by two mountains, ſtone dykes were conſtructed at a conſiderable height up the hills, and extended from thence to the lower part of the valley, always drawing nearer to each other, till they approached within three or four feet. This narrow paſs opened into a circular ſpace, incloſed by a wall of ſufficient height to reſtrain the deer, which were purſued hither and deſtroyed. The remains of one of theſe ancient deer-traps are ſtill to be traced. Birds of prey are numerous in Rum; and there are likewiſe a few grouſe, pigeons, termagants, and wild ducks, beſides thoſe birds which frequent the iſland only at ſtated ſeaſons of the year. The air of Rum, from its proximity to the weſtern ocean, is moiſt, and the weather extremely rainy. The only harbour here is Loch-Screfort, which penetrates a conſiderable way into the iſland, on its eaſtern coaſt. It is ſpacious, its ground good, and its depth of water from five to ſeven fathoms. Near the head, on the ſouth ſide of this harbour, a pier has been lately erected. The general appearance of Rum is, that the land ſlopes towards the eaſt; but on the weſt preſents precipices of a tremendous height. At the baſe of the hill Sgormor are found abundance of agates, of that ſpecies called by Cronſtedt "Achates chalcedoniſans," improperly white cornelians. Here are ſeveral remarkable ſtrata; ſuch as grey quartz; a mixture of quartz and baſaltes; a black ſtone ſpotted with white, like porphyry, but with the appearance of lava; fine grit or free-ſtone; and the cinereous indurated bole of Cronſtedt. There being no mill in this iſland, the corn is "gradanned," or burnt out of the ear, inſtead of being thraſhed. This is performed in two ways: firſt by cutting off the ears and drying them in a kiln, and then ſetting fire to them on the floor, and picking out the grains; and ſecondly, by burning the ſheaf entire, which is a moſt ruinous practice, as it deſtroys both thatch and manure. Gradanned corn is conjectured to have been the parched corn of holy writ.

Rum not being a pariſh of itſelf, its population is not ſtated in the parliamentary returns; but it is eſtimated to contain about 500 inhabitants. The Statiſtical Account of Scotland, by ſir John Sinclair, bart. 8vo. vol. xvii. 1796. Beauties of Scotland, vol. v. 8vo. 1808. Carliſle's Topographical Dictionary, 4to. 1813.

Saccharometer

SACCHAROMETER, in the *Arts*, an inftrument for afcertaining the value of worts, and the ftrength of different kinds of malt-liquor. The name fignifies a meafurer of fweetnefs, and the inftrument feems to depend on the following principles. The water employed by the brewer becomes more denfe, that is, of a greater fpecific gravity, by the addition of materials extracted by, and diffolved in it, and thence, in fact, incorporated with it: the operation of boiling, and its evaporation in the fubfequent cooling, ftill augment the fpecific gravity, fo that when it is fubmitted to the action of fermentation, it is found to be denfer than at any other period. In paffing through this natural operation, a remarkable operation takes place. The fluid, as foon as it begins to ferment, begins alfo to diminifh in its denfity, and as the fermentation is more or lefs perfect, the fermentable matter, whofe acceffion has been traced by the increafe of denfity, becomes more or lefs attenuated, and a fpirituous fluid, of lefs denfity than water, is produced; fo that when the liquor is again in a ftate of reft, it is fo much fpecifically lighter than it was before, as the action of fermentation has been capable of attenuating the liquid of its acquired denfity; and if the whole were affected in like manner, the liquor would become lighter, or of lefs fpecific gravity than water, becaufe the quantity of fpirit produced from the fermentable matter, and occupying its place, would diminifh the denfity of the water in fome fort of proportion to that in which the latter was increafed. Such is the account given of the faccharometer, and the theory of its action. On this fubject it has been afked if the faccharometer is an inftrument which truly indicates the ftrength of malt-liquor; and are the conftituents of malt always diffolved in the fame proportions to each other? becaufe unlefs this be the cafe, there can be but little dependence placed upon it. To this it has been anfwered, by a very modern writer, that the faccharometer indicates correctly the fpecific gravity of the wort before it begins to ferment. The value of the beer or ale, fuppofing the procefs properly conducted, always depends upon the ftrength, that is, the fpecific gravity, becaufe the fame fubftances are always taken up from good malt; and the real value of beer, to fay nothing of the market price, is always proportional to the fpecific gravity of the wort. See HYDROMETER.

Another writer on the fubject (fee Dr. Thompfon's Annals). obferves, that according to the common acceptation of the word *ftrength*, in beer or ale, the faccharometer foretels it fufficiently near the truth, for *fimilar* proceffes in the *fame* brewhoufe, but it is by no means a fure guide for any diffimilarity in the mode of brewing, or of drawing the extract; for then the conftituents of malt are *not* often diffolved in the fame proportion to each other, and in all cafes the extracts are fuperior in value according to their priority. For, let the firft, from the fame parcel of malt, be reduced to the fpecific gravity of the laft, and an equal quantity of each will give a beer very different in quality.

The quantity of alcohol increafes during fermentation, as the fpecific gravity of the fermenting fluid diminifhes, but in what ratio no correct experiments have as yet afcertained. The term defignated *ftrength*, in malt liquors, depends, however, on many inexplicable circumftances. It is neverthelefs certain that the common faccharometer does not give the quantity of folid matter contained in a given quantity of wort, it fhews merely the difference of weight between that and the fame quantity of water.

Sail-making

SAIL-*Making*. By act of parliament for encouraging the use and consumption of the manufacture of British sail-cloth, every ship or vessel which shall be built in Great Britain, and every ship or vessel which shall be built in any of his majesty's plantations in America, shall, upon her first setting out to sea, have or be furnished with one full and complete suit of sails, made up of sail-cloth manufactured in Great Britain; and in case such ship shall not, on her first setting out, be so fitted out and furnished, that then, and for every such neglect and default, the master of such ship shall forfeit the sum of fifty pounds.

It is likewise enacted, that all sail-cloth made in Great Britain shall be manufactured in the manner, and according to the directions hereafter mentioned, *viz.* every piece or bolt of British sail-cloth, that shall be twenty-four inches in breadth, and thirty-eight yards in length, shall weigh according to the number and weights here mentioned: *viz.* N° 1, 44 pounds each bolt; N° 2, 41; N° 3, 38; N° 4, 35; N° 5, 32; N° 6, 29; N° 7, 24; N° 8, 21; N° 9, 18; and N° 10, 15 pounds each bolt.

And in case any piece or bolt of either such respective numbers or sorts of British sail-cloth shall be made of a different breadth or length than before-mentioned, such piece or bolt of British sail-cloth shall be increased or diminished in weight, in proportion to the difference in length or breadth, and shall be marked or stamped with such number

as shall be agreeable to the weight; and the warp or chain of every piece or bolt of the first six numbers of such British sail-cloth, shall be wholly wrought and made of double yarn, and shall contain in every piece or bolt of twenty-four inches in breadth, at least 560 double threads of yarn; and in every piece of such sail-cloth, that shall be thirty inches in breadth, at least 700 double threads of yarn; and in every bolt of such sail-cloth, that shall be of any other breadths than as aforesaid, a certain number or quantity of double threads of yarn, in proportion to the number of double threads of yarn expressed to be contained in the breadth, as aforesaid; and the warp and shoot-yarn, which shall be wrought in every piece or bolt of the first four numbers of such sail-cloth, shall be made of long flax, without any mixture of short or bar flax; or of long flax, of Italian hemp, or Braak hemp; and all the flax and hemp used in making the warp and shoot-yarn of such sail-cloth, of the aforesaid four first numbers, shall be of a strong staple, fresh, sound, and good in its kind, and well dressed, and the yarn well cleansed, even spun, and well twisted; and all the shoot-yarn of each piece of sail-cloth of the four first numbers, shall be full as strong as the warp-yarn, and close struck with four shoots of treble threads at the distance of every two feet, or thereabouts; and both the warp and shoot-yarn shall be as strong as the warp and shoot-yarn that are usually wrought in the sail-cloth of those four first numbers that are made for and used in his majesty's navy; and no flax-yarn used in any British sail-cloth shall be whitened with lime, on forfeiture of sixpence *per* yard, for every yard that shall be so whitened, made, sold, or worked up into new sails in Great Britain, any way essentially different, lighter, or inferior in strength and goodness to any of the aforesaid directions or restrictions.

Every sail-maker, or other person who shall make or work up sail-cloth into sails or tarpawlins, shall cause this act, or an abstract thereof, to be put up or affixed, there to continue, in some public part of the loft, shop, or workhouse, where his said trade is carried on, or his workmen employed, under the penalty of forty shillings.

The several acts relative to sail-cloth and sail-making are the act of the 7 & 8 W. III. c. 10. § 14. 9 & 10 W. III. c. 41. 9 Geo. II. c. 37. 19 Geo. II. c. 27. 33 Geo. III. c. 49.

The First Process in Sail-making

Is the cutting out the various sails cloth by cloth, the width being governed by the length of the yard, gaff, boom, or stay, to which they bend; the depth by the height of the mast. The width and depth being given, find the number of cloths the width requires, allowing for seams, slack-cloth for sewing on the bolt-rope, and tabling on the leeches; and in the depth allow for tabling on the head and foot. For sails cut square on the head and foot, with gores only on the leeches, as some topsails, &c. the cloths on the head, between the leeches, are cut square to the depth; and the gores on the leeches are found by dividing the depth of the sail by the number of cloths gored, which gives the length of each gore. The gore is set down from a square with the opposite selvage, and, the canvas being cut diagonally, the longest gored side of one cloth makes the shortest side of the next; consequently, the first gore being known, the rest are cut by it.

For the length of gores corresponding to the depth on the selvage, consult the following table, which shews the length of any gore by its depth, from one inch to six feet in depth on the selvage of canvas twenty-four inches wide.

Depth down the Selvage.		Length of the Gore.		Depth down the Selvage.		Length of the Gore.		Depth down the Selvage.		Length of the Gore.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	1	2	0	2	1	2	10¾	4	1	4	7
0	2	2	0 1/16	2	2	2	11½	4	2	4	7⅞
0	3	2	0⅛	2	3	3	0¼	4	3	4	8¾
0	4	2	0¼	2	4	3	1	4	4	4	9⅝
0	5	2	0⅜	2	5	3	1¾	4	5	4	10½
0	6	2	0½	2	6	3	2½	4	6	4	11⅜
0	7	2	0¾	2	7	3	3¼	4	7	5	0¼
0	8	2	1⅛	2	8	3	4⅛	4	8	5	1⅛
0	9	2	1½	2	9	3	5	4	9	5	2
0	10	2	1⅞	2	10	3	5⅞	4	10	5	2⅞
0	11	2	2¼	2	11	3	6¾	4	11	5	3¾
1	0	2	2¾	3	0	3	7⅝	5	0	5	4⅝
1	1	2	3¼	3	1	3	8½	5	1	5	5½
1	2	2	3¾	3	2	3	9⅜	5	2	5	6⅜
1	3	2	4¼	3	3	3	10¼	5	3	5	7¼
1	4	2	4¾	3	4	3	11⅛	5	4	5	8⅛
1	5	2	5¼	3	5	4	0	5	5	5	9
1	6	2	5¾	3	6	4	0⅞	5	6	5	10
1	7	2	6½	3	7	4	1¾	5	7	5	11
1	8	2	7	3	8	4	2⅝	5	8	6	0
1	9	2	7¾	3	9	4	3½	5	9	6	1
1	10	2	8½	3	10	4	4⅜	5	10	6	2
1	11	2	9¼	3	11	4	5¼	5	11	6	3
2	0	2	10	4	0	4	6⅛	6	0	6	4

In the leeches of topsails cut hollow, the upper gores are longer than the lower ones; and in sails cut with a roach-leech, the lower gores are longer than the upper ones. This can only be regulated by the judgment of the sail-maker, and care must be taken that the whole of the gores do not exceed the depth of the leech.

Sails gored with a sweep on the head or foot, or on both, have the depth of their gores marked on the selvage from the square of the given depth on each cloth, and are cut out as above; the longest selvage of one serving to measure the shortest selvage of the next, beginning with the first gored cloth next the middle in some sails, and the first cloth next the mast-leech in others.

For those gores that are irregular, and likewise the hollow leeches of topsails, &c. no strict rule can be given; but by drawing on paper the gored side of the sail, and delineating the breadth of every cloth by a convenient scale of equal parts of an inch to a foot, or, what would be better, laying-off the full size of the sail on the loft-floor, the length of every gore may be found with precision.

In the royal navy, mizen-topsails are cut with three-quarters of a yard hollow in the foot; but, in the merchant service, top and topgallant-sails are cut with more or less hollow in the foot. Flying jibs are cut with a roach-curve on the stay, and a three-inch gore in each cloth, shortening from the tack to the clue.

Lower studding-sails are cut with square leeches, and topmast and topgallant-mast-studding-sails with goring leeches.

For the cutting of all other sails, we refer to the particular description of each sail, which follows.

Tablings of all sails are to be of a proportionable breadth to the size of the sail. Those for the heads of main and fore-courses to be from 4 to 6 inches wide; for sprit-courses and mizens, drivers, and other boom-sails, 3 to 4 inches wide;

for top-fails, 3 to $4\frac{1}{2}$ inches; topgallant and fprit-topfails, 3 inches; royal fails, $2\frac{1}{2}$ inches; jib and other ftay-fails, 3 to $4\frac{1}{2}$ inches, on the ftay or hoift; and for ftudding-fails, 3 to 4 inches on the head.

Tablings on the foot and leeches of main and fore-courfes to be from 3 to 5 inches broad; fprit-courfe and topfails, 3 inches; topgallant and fprit-topfails, $2\frac{1}{2}$ inches; royals, 2 inches; fore-leeches of mizen, driver, and other boom-fails, $3\frac{1}{2}$ to 4 inches; after-leech, 3 inches; and on the foot, 2 to 3 inches.

Tablings on the after-leech of jibs and other ftayfails to be from 2 to 3 inches broad; and on the foot, 2 to $2\frac{1}{2}$ inches; on ftudding-fail-leeches, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches; and on the foot, from 1 to 2 inches.

The length of reef and middle bands is governed by the width of the fail at their refpective places: the leech-linings, buntline-cloths, top-linings, maft-cloths, and corner-pieces, are cut agreeable to the depth of the fail. Each cloth, and every article when cut, fhould be properly marked with charcoal, to prevent confufion or miftake.

Reef-bands.—Main and fore-courfes have two reef-bands; the upper one is one-fixth of the depth of the fail from the head, and the lower band fhould be the fame diftance from the upper one, the ends going four inches under the leech-linings. The breadth one-third the breadth of the canvas.

Main and fore-topfails have four reef-bands, or three at leaft, from leech to leech, over the leech-linings; the upper one to be one-eighth of the depth of the fail from the head. They are the fame diftance afunder in the royal navy, but more in the merchant fervice. Mizen-topfails of 50-gun fhips, and upwards, have three reefs; the upper one is one-eighth of the depth of the fail from the head, and the reefs are the fame diftance afunder. Mizen-topfails of leffer fhips have two reefs one-feventh the depth of the fail from the head, and the fame diftance afunder. The reef-bands have each half a breadth of canvas. Main and main-top-ftudding-fails have each one reef, at one-eighth of the depth of the fail from the head.

The *middle band* is made of one breadth of canvas of the fame number as the top-linings, and is put on half way between the lower reef and the foot.

Linings.—Main and fore-courfes are lined on the leeches, from clue to earing, with one cloth. Main, fore, and mizen-topfails, have leech-linings made of one breadth of cloth, fo cut as to be half a cloth broad at the head, and a cloth and a half broad at the foot; the cloth to be cut from half its breadth at one end, fo as to taper to a point at the other.

Mizens are lined with one breadth of cloth from the clue five yards up the leech; they have alfo a nock-piece, and a peek-piece, one cut out of the other, fo that each contains one yard.

The maft-lining is of two cloths, and extends from the foot of the fail to the lower reef, to receive the beat or chafe of the maft.

The top-lining of top-fails is of canvas N° 6 or 7. The other linings of this and all other fails fhould be of the fame quality as the fails to which they belong.

Lower ftayfails, fore-top and main-top-ftayfails, and flying jibs, have clue-pieces two yards long.

Square tack-ftayfails have half a breadth of cloth at the fore-part; with a clue-piece containing two yards, and a peek-piece containing one yard.

Buntline-Cloths.—Main and fore-courfes have four buntline-cloths, and all topfails two buntline-cloths, from the foot to the middle band, of one breadth of canvas.

Sails to have bonnets are cut out the whole depth of the fail, bonnet included, allowing enough for the tablings on the foot of the fail, and head and foot of the bonnet. The bonnet is cut off after the fail is fewed together. If a drabbler is required, it is allowed for in the cutting out the fame, as in the bonnet.

The Second Procefs in Sail-making

Is the fewing of the various parts of a fail together; and, firft, the

Seams.—Sails have a double flat feam, and fhould be fewed with the beft Englifh-made twine of three threads, fpun 360 fathoms to the pound, and to have from 108 to 116 ftitches in every yard in length.

The twine for fewing main, fore, mizen, and fprit-courfes, topfails, and ftayfails, in the royal navy, is waxed by hand with genuine bees-wax, mixed with one-fixth part of clear turpentine; and for fmall fails, in a mixture made of bees wax 4 lb., hog's-lard 5 lb., and clear turpentine 1 lb. In the merchant fervice, the twine is dipped in tar, foftened with a proper proportion of oil.

The breadth of the feams of courfes, topfails, and other fails in the royal navy, to be as follow; *viz.* courfes and topfails, for 50-gun fhips and upwards, $1\frac{1}{2}$ inch; thofe under 50 guns, $1\frac{1}{4}$ inch, at head and foot; all other fails, one inch at head and foot.

In the merchant fervice, feams are fometimes made broader at the foot than at the head, being ftronger.

Broad feams are not allowed to be made on courfes in the royal navy, but goring leeches are adopted in lieu of them.

Driver boom-main-fails, and the fails of floops, generally have the feams broader at the foot than at the head.

It is the erroneous practice of fome fail-makers not to few the feams any farther than where the edge is creafed down for the tabling; but all fails fhould be fewed quite home to the end, and, when finifhed, fhould be well rubbed down with a rubber.

The feams of courfes and topfails are ftuck or ftitched up, in the middle of the feams along the whole length, with double feaming-twine; and have from 68 to 72 ftitches in a yard. In the merchant fervice, it is common to ftick the feams with two rows of ftitches when the fail is half worn, as they will then laft till the fail is worn out.

Tablings of all fails to be fewed at the edge, with 68 to 72 ftitches in a yard.

Reef-bands are each in breadth one-third of the breadth of the canvas for main and fore-courfes. The reef-bands of main and fore-topfails are each of half a breadth of canvas, put on double; the firft fide is ftuck twice, and the laft turned over, fo that the reef-holes may be worked upon the double part of the band; the ends go four inches under the leech-linings, which are feamed over the reef-bands. The reef-bands of topfails go over the linings from leech to leech, and are ftuck with 68 to 72 ftitches in a yard. Reef-bands fhould not be put on until the fail is fewed up, a contrary practice being very erroneous.

Middle bands have one breadth of canvas, and are firft folded and rubbed down, to make a creafe at one-third of the breadth; then tabled on the felvage, and ftuck along the creafe; then turned down, and tabled and ftuck through both the double and fingle parts, with 68 to 72 ftitches in a yard. They are likewife tabled or fewed over the ends of the buntline-cloths and top-linings.

It is the opinion of many, that middle bands fhould not be put on until the fail is half worn.

Linings.—All linings are feamed on, and are ftuck, or ftitched, in the middle, with 68 to 72 ftitches in a yard.

Top-linings and maſt-cloths are put on the aftſide, and all other linings on the foreſide, of ſails.

Holes.—Reef and head-holes are made by an inſtrument, called a pegging-awl, or a ſtabber, and are fenced round by ſtitching the edge to a ſmall grommet, made with log or other line: when finiſhed, they ſhould be well ſtretched or rounded up by a pricker, or a marline-ſpike.

Sails have two holes in each cloth, at the heads and reefs of courſes, topſails, and other ſquare ſails; one hole in every yard in the ſtay of flying jibs; and one in every three-quarters of a yard in the ſtays of ſquare, tack, and other ſtayſails.

Reef and head-holes of large ſails have grommets of 12-thread line, worked round with 18 to 21 ſtitches; ſmaller ſails have grommets of 9-thread line, with 16 to 18 ſtitches, or as many as ſhall cover the line; and ſmaller holes in proportion.

The holes for marling the clues of ſails, and the top-brims of topſails, have grommets of log-line, and ſhould have from 9 to 11 ſtitches: 12 holes are worked in each cloth.

Main-courſes have marline-holes from the clue to the lower bowline-cringle up the leech; and from the clue to the firſt buntline-cringle on the foot. Fore-courſes have marline-holes one-eighth of the depth of the ſail up the leech, and from the clue to the firſt buntline-cringle at the foot. Main and fore-topſails have marline-holes three feet each way from the clue, and at the top-brims. Spritſails, mizen-topſails, lower ſtayſails, main and fore-top-ſtayſails, and jibs, have marline-holes two feet each way from the clues. All other ſails are ſewed home to the clues.

Marline-holes of courſes are at three-fourths of the depth of the tablings at the clues from the rope, and thoſe of topſails are at half the depth of the tablings at the clues and top-brim from the rope.

Bonnets have a head-tabling, to which a line that forms the latchings is ſewed in bights, which are about ſix inches aſunder; the leeches and foot are tabled, &c. ſimilar to the foot of the ſail the bonnet is attached to.

The Third Proceſs in Sail-making

Is ſewing on the bolt-rope, &c.

Bolt-ropes, before ſewed, ſhould be ſtoved in a ſtove by the heat of a flue, and not in a baker's oven, or in a ſtove-tub; and tarred with the beſt Stockholm tar; to be ſewed on with good Engliſh-made twine of three threads, ſpun 200 fathoms to the pound. The twine in the royal navy is dipped in a compoſition made with bees-wax, four pounds; hog's-lard, five pounds; and clear turpentine, one pound; and in the merchant ſervice, in tar ſoftened with oil.

Bolt-ropes of courſes, top-ſails, and all other ſails, ſhould be neatly ſewed on through every cunt-line of the rope; and to avoid ſtretching, the rope muſt be kept tightly twiſted while ſewing on, and care taken that neither too much nor too little ſlack is taken in: they are to be croſs-ſtitched at the leeches every twelve inches in length, at every ſeam, and in the middle of every cloth at the foot, with three croſs-ſtitches. Four croſs-ſtitches ſhould be taken at all beginnings and faſtenings-off; the firſt ſtitch given twice, and the laſt three times. Small ſails have two croſs-ſtitches at every ſeam, and three at every faſtening-off.

The number of threads required in the royal navy for ſewing on the following ſized bolt-ropes; *viz.* 6-inch, 10 ordinary and 2 extra; $5\frac{3}{4}$ and $5\frac{1}{2}$, 10 ordinary; $5\frac{1}{4}$ and 5-inch, 8 ordinary and 2 extra; $4\frac{3}{4}$ and $4\frac{1}{2}$, 8 ordinary; $4\frac{1}{4}$ and 4-inch, 6 ordinary and 2 extra; $3\frac{3}{4}$ and $3\frac{1}{2}$, 6 ordinary; $3\frac{1}{4}$ and 3-inch, 4 ordinary and 2 extra; $2\frac{3}{4}$ and $2\frac{1}{2}$, 4 ordinary; $2\frac{1}{4}$ and 2-inch, 2 ordinary and 2 extra; $1\frac{3}{4}$, $1\frac{1}{2}$, $1\frac{1}{4}$, and 1-inch, 2 threads ordinary.

Slack allowed in ſewing on Bolt-ropes.—On main and fore-courſes two inches ſlack-cloth ſhould be allowed in the head and foot, and one inch and a half on the leeches, in every yard in length.

Mizen-courſes have two inches ſlack in every yard in the fore-leech, but none in the after-leech or foot.

Spritſail-courſes have no ſlack-cloth.

Topſails are allowed three inches ſlack in every cloth in the foot, and one inch and a half in every yard in the leech, and two inches in every cloth left open in the top-brim.

Topgallant-ſails have two inches ſlack in every cloth in the foot, and one inch in every yard in the leech.

Jibs have four inches ſlack in every yard on the ſtay, one inch in every cloth in the foot, and none on the leech.

Stayſails have three inches ſlack in every yard on the ſtay, one inch in every cloth in the foot, but none on the leech.

Studding-ſails have one inch and a half ſlack in every yard in goring-leeches, but no ſlack on ſquare-leeches, and one inch in every cloth on the head and foot.

The clues and top-brims ſhould be wormed while the bolt-rope is ſewing on the ſail, and before both parts are confined.

Clues.—Fourteen turns or twiſts of the ſtrands in the length of the clue-rope are left at the lower corners of all ſails for the clues, which are wormed with ſizeable ſpun-yarn, parcelled, ſerved, marled, and ſeized. The clue-ropes of main-courſes extend, and are marled, from the clue to the lower bowline-cringle up the leech, and to the firſt buntline-cringle on the foot; on fore-courſes one-eighth of the depth of the ſail up the leech, and to the firſt buntline-cringle on the foot; the clue-ropes of main and fore-topſails extend three feet each way on the leech and foot: and ſpritſails, mizen-topſails, lower ſtayſails, main and fore-top-ſtayſails, and jibs, have the clue-rope two feet each way from the clue.

Cringles.—Cringles ſhould be made of the ſtrands of new bolt-rope, half an inch ſmaller than the bolt-rope on the ſail.

Earing-cringles are made of an additional length (of fourteen twiſts or turns) of the leech-rope left at the head of the ſail, which, being turned back, forms the cringle, by ſplicing its end into the leech-rope and croſs-ſtitching the whole of the ſplice; the firſt ſtitch to be given twice, and the laſt ſtitch three times.

Splices are made by opening the ends of two ropes, and placing the ſtrands between each other: openings being made in the untwiſted part of the rope neareſt the end with a marline-ſpike, the ſtrands are thruſt through them; and the large ends are regularly tapered from the middle by cutting away ſome of the yarns every time they are thruſt through. The ſmall ſtrands, as thoſe of the foot or leech-rope, are ſtuck twice through the openings made in the large rope; and the large ſtrands are ſtuck three times through the leech or foot-rope. The middle ſtrand of the taper, being the longeſt, is ſtuck in laſt, and once more than the others. All ſplices are croſs-ſtitched as far as they run.

Reef and reef-tackle pendant-cringles are ſtuck through holes made in the tablings, and the lower ends are put through the bolt-rope once more than the upper ends, being more liable to be drawn out.

The openings of buntline and bowline-cringles are at the diſtance of four turns or twiſts of the ſtrands in the bolt-

rope afunder, and the ends are firft ftuck in an opening, made with a marline-fpike, under two ftrands of the bolt-rope; then paffing over the next, they are ftuck under one ftrand; and again paffing over another, they are finally ftuck under the next. The ends of the buntline-cringles, next the fervice of the clues of courfes, fhould be left long enough to be worked under the fervice, to meet or reach the ends of the clue-rope. See *Plate* I. *fig*. 26.

Rules for afcertaining the Quantity of Canvas contained in the different Sails.

Canvas 24 inches wide is ufed for the royal navy, and is certainly the ftrongeft. Various widths of canvas are ufed in the merchant fervice, from 24 to 36 inches. The following rules are adapted equally to all widths, although the examples are calculated for canvas 24 inches wide.

Rule 1.—*To find the quantity of canvas in main and fore-courfes; topfails; topgallant-fails; royals; topmaft and topgallant-ftudding-fails.*

Add the number of cloths in the head and foot, and halve the product, to make it fquare; then multiply by the depth of the middle cloth; and add the quantity in the linings, bands and pieces, and the quantity in the foot-gores, when the foot is cut hollow.

To find the quantity in the foot-gores.

Add together the number of inches gored in each cloth on one fide of the fail, and multiply the product by half the number of gored cloths, and divide by 36, to bring that into yards.

Rule 2.—*To find the quantity of canvas in a mizen-courfe.*

Add the depth of the fore and after-leech together, and halve the product for a medium depth; then multiply the medium depth by the number of cloths; and add to that the additional canvas contained in the linings, bands, pieces, and foot-gores.

To find the quantity in the foot-gores.

The number of cloths in the fail muft be multiplied by the additional length, that the fquare cloth in the middle is more than thofe at the tack and clue; then, the gores to the tack and clue being fubtracted, the remainder is the quantity in inches, which divided by 36 gives the number of yards.

Rule 3.—*To find the quantity of canvas contained in fprit-fail-courfes; lower ftudding-fails; floop's fquare fails, or crofs-jack; and floop's water-fails.*

Multiply the number of cloths by the fhorteft depth, add the quantity in the bands and pieces, and the quantity in the foot-gores, when the foot is cut hollow; by Rule 1.

Rule 4.—*To find the quantity of canvas contained in driver-boom-fails; brig's main-fails; cutter's main-fails; cutter's try-fails; likewife floop's and fmack's.*

Add together the number of cloths in the head and foot, and halve the product to make it fquare; add together the depth of the fore and after-leeches, and halve that fum for a medium depth; then multiply the number of fquare cloths by the medium depth, and add the quantity in the pieces and foot-gores.

To find the quantity in the foot-gores.

Add together the gores from the tack to the firft fquare cloth in the foot, and multiply half the fum by the number of cloths in the foot; then (if there are gores to the clue) add together the gores from the clue to the firft fquare cloth in the foot, and multiply half the fum by the number of cloths gored to the clue; which fubtracted from the product of the gores to the tack, gives the anfwer.

Rule 5.—*To find the quantity of canvas contained in jibs; main and fore-ftayfails; fore-topmaft ftayfails; floop's, fmack's, and boat's fore-fails and latteen-fails.*

Multiply half the number of cloths by the depth of the leech, and add the quantity in the bands, pieces, and foot-gores, if any.

To find the quantity in the foot-gores.

Multiply half the number of cloths in the foot by the regular gore *per* cloth, and that product multiplied by the whole number of cloths in the foot gives the anfwer in inches, which divide by 36, to bring into yards.

Rule 6.—*To find the quantity of canvas contained in mizen-ftayfails; main-topmaft-ftayfails; mizen-topmaft-ftayfails; middle ftayfails; main-topgallant-ftayfails; gaff-topfails; ringtail-fails; fettee-fails; and boat's fpritfails.*

Add the depth of the tack, bunt, or fore-leech, to the depth of the after-leech, and halve them for a medium depth: add the number of cloths in the head and foot together, (when not equal,) and halve them, to reduce them fquare; then multiply the number of fquared cloths by the medium depth, and add to that the additional canvas contained in the linings, bands, and pieces.

Deſcription of each Sail.

MAIN-COURSE, 1. *Plate* IV. *Rigging, fig.* 2.

This ſail is quadrilateral, ſquare on the head. It bends at the head to the main-yard, and extends within eighteen inches of the cleats on the yard-arms, and drops to clear the foot from the boat on the booms.

Guns	Sort of Canvas.	110	98	80	74	50	44	38	36	24	18	16	Main-ſail. Brig.	Main-ſail. Cutter.
Tons		2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the head	N°	48	46	48	47	40	40	39	38	31	28	27	12½	24
Number of cloths in the foot	1	50	48	50	49	42	42	41	40	33	30	29	19½	34
Depth in yards		14½	14	16½	16	13	13½	13¼	13¼	11	10	9½	13 8¾	24 18
Yards in the ſail		710½	658	808½	768	533	553½	540	516¾	352	290	266	174	609
——— reef-bands	1	19	18¾	22	20	17	17	16½	16	13	12	11½	21	27
													Peek-Piece.	
——— middle band	5 to 6	30	28½	31	30	26	26	25¼	25	20	18½	17½	1	2
——— leech-linings	1	33½	31¾	37	35¾	28½	29½	29	29	24½	22¾	22	8¾	18
													Clue-Piece.	
——— buntline-cloths	1	19	18½	23	21½	17½	17¾	17	17	14	13½	13	5	8
——— gores	1	18¾	14¼	19¼	14½	8	9½	8¾	8¾	8	9	9	3½	45
Totals		830¾	769¾	940¾	889¾	630	653¼	636½	612½	431½	365¾	339	213¼	709
		Inches.											Maſt-Leech.	
													3	3
Bolt-rope on the head		2½	2½	2½	2½	2	2	1¾	1¾	1½	1½	1½	1½	1½
Bolt-rope on the foot		6	5¾	6	5¾	5	4¾	4½	4½	4	3½	3½	1¾	1¾
Bolt-rope on the leeches		6	5¾	6	5¾	5	4¾	4½	4½	4	3½	3½	1¾	1¾

Gores.—One cloth is gored on each *leech*; and the gore on the *foot* is of one inch *per* cloth, beginning at two cloths within the neareſt buntline-cringle, and increaſing to the clues. Sometimes, in merchant-ſhips, two cloths are gored on the leeches, and the gore on the foot is two inches *per* cloth.

For *tablings*, *reef-bands*, *middle bands*, and *buntline-cloths*, conſult the firſt proceſs in ſail-making; and ſewing them on, the ſecond proceſs; likewiſe the *ſeams*, *reef*, and *head-holes*.

In ſewing on the bolt-rope, two inches of *ſlack-cloth* ſhould be taken up in every cloth in the head and foot, and one inch and a half in every yard in the leeches.

Clues are made with clue-rope two inches larger than the foot-rope, for ſhips of 50 guns and upwards; and one inch and a half larger for ſhips under 50 guns; and thoſe in merchant-ſhips are in proportion.

Marline-holes extend from the clue to the lower bowline-cringle on the leech; and to the firſt buntline-cringle at the foot.

Reef-cringles: one is made on the leeches at the end of each reef-band; three bowline-cringles are made at equal diſtances between the lower reef-cringle and the clue; and *buntline-cringles* are made on the *foot-rope*, one at the end of each buntline-cloth.

To find the quantity of canvas, refer to Rule 1.

FORE-COURSE, 5. *Plate* IV. *fig*. 2.

This fail is quadrilateral, fquare on the head. It bends at the head to the fore-yard, and extends within eighteen inches of the cleats on the yard-arms, and drops to clear the foot of the main-ftay.

Guns	Sort of Canvas.	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons		2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the head	N° 1 to 2	42	40	41	40	35	35	34	33	27	25	24	19
Number of cloths in the foot		40	38	39	38	33	34	33	32	24	24	23	18
Depth in yards		12¼	11½	13½	13	11½	11½	11	11	9	9	8¾	7½
Yards in the fail		502¼	448½	540	507	391	396¼	368½	357½	238½	220½	205	138¾
—— reef-bands	1 to 2	17½	16	17¼	17	13¾	13¾	14½	13½	10[illegible]	10¾	10	7
—— middle band	5 to 6, 7	24½	23	24½	24½	21½	21½	20	19½	15⅞	15½	14½	11½
—— leech-linings	1 to 2	27¼	26	30	29½	24	24½	24	24	20	20	19½	16½
—— buntline-cloths	1 to 2	16	15¾	18¼	17½	14¼	14¾	14	14	12	12	11¼	7½
—— gores	1 to 2	11	10¾	10½	10	6	6	5¾	5¾	5⅞	5½	5¼	3¼
Totals		599	540	640½	605½	470½	477¼	446¾	434¼	303⅛	284¼	266⅝	184½
		Inches.											
Bolt-rope on the head		2¼	2¼	2	2	1¾	1¾	1¾	1¾	1½	1½	1¼	1¼
Bolt-rope on the foot		5½	5¼	5	5	4¼	4¼	4	4	3½	3	2½	2½
Bolt-rope on the leeches		5½	5¼	5	5	4¼	4¼	4	4	3½	3	2½	2½

Gores.—One cloth is gored on each *leech*, and a gore is made on the *foot*, to drop the clue five to fix inches *per* cloth, beginning at two cloths within the neareft buntline-cringle, and increafing to the clues. Sometimes two cloths are gored on each leech in merchant-fhips.

This fail only differs from the former in the *buntline-cringles* having only two; the upper bowline-cringle is made in the middle of the leech, and the lower one equally diftant from the upper one and the clue.

Marline-holes are made in the tabling, from the clue to the neareft buntline-cringle on the foot, and one-eighth of the depth of the fail up the leech. They are turned on the contrary fide to the roping, in fixing the fail.

To find the quantity of canvas, refer to Rule 1.

MIZEN-COURSE, 9. *Plate* IV. *fig*. 2.

This fail is quadrilateral, and made of canvas N° 2, from 36 guns and upwards; N° 3, to 24 guns; and to 16 guns N° 4. The head is bent to the gaff, and extends within nine inches of the cleats. The fore-leech is attached to the mizen-maft within fix or feven feet of the deck.

Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head	17	16	16	16	13	13	13	13	10	9	9
Number of cloths in the foot	18	17	17	17	14	14	14	14	11	10	10
Depth of the leech in yards, fore	10½	9½	11	11	8½	11½	11¼	10¾	9	8	7¾
Depth of the leech in yards, aft	20½	19½	21	21	16¼	18½	18¼	18¼	15½	14½	13½
Yards in the fail	271¼	239¼	264	264	167	202½	199⅛	195¾	122½	103⅞	100¾
—— reef-band	3¾	3½	3½	3½	2¾	3	3	3	2	2	2
—— nock and peek-pieces	2	2	2	2	2	2	2	2	2	2	2
—— clue-pieces	5	5	5	5	5	5	5	5	5	5	5
—— gores	10	9	9½	9½	6	7½	7	7	5	4½	4
Totals	292	258¾	284	284	182¾	220	216⅛	212¾	136½	117⅜	113¾
	Inches.										
Bolt-rope on the head	1¾	1¾	1¾	1¾	1½	1½	1½	1½	1½	1½	1½
Bolt-rope on the foot	3½	3¼	3	3	2½	2½	2¼	2¼	2	1¾	1¾
Bolt-rope on the fore-leech	4½	4¼	4	4	3	2¾	2½	2½	2½	2¼	2¼
Bolt-rope on the after-leech	3¼	3	3	3	2½	2¼	2¼	2¼	2	1¾	1¼

Gores.—The head is cut with a gore of 16 to 22 inches *per* cloth, agreeable to the peek: the foot is gored one inch *per* cloth, leaving two cloths ſquare in the middle. One cloth is gored on the maſt-leech in the navy, and ſometimes two cloths in merchant-ſhips.

For *ſeams, tablings,* and *head-holes,* conſult the three proceſſes in ſail-making.

This ſail has a *reef-band* ſix or eight inches broad, at one-fifth of the depth of the maſt-leech from the foot.

Reef-hanks are pieces of log-line ſewed on to the reef-band, at each ſeam on both ſides of the ſail. One end of each hank is ſpread open, and each ſtrand ſecurely ſewed; the other end of each hank is whipped: or they may be fixed on thus: the line is thruſt through the ſail, and ſecurely ſewed to it on one ſide, by opening the ſtrands a little, ſo as to lay them flat on the canvas.

Lining.—The after-leech is lined from the clue with one breadth of canvas up the leech, and the *nock* and *peek* with pieces ſo cut from each other, that each contains one yard.

Marline-holes extend two feet each way from the clue.

Bolt-rope-clue, and ſewing it on, conſult the third proceſs in ſail-making.

One *cringle* is made on each leech at the ends of the reef-band; and one at the diſtance of every three-quarters of a yard on the maſt-leech; or ſometimes holes are worked in the tabling of the maſt-leech; a cringle is alſo made five yards from the clue on the after-leech for the throat-brails.

To find the quantity of canvas, refer to Rule 2.

SPRITSAIL-COURSE, 13. *Plate* IV. *fig.* 2.

This ſail is quadrilateral, ſquare on the head, foot, and leeches, and made of canvas N° 2, from 50 guns and upwards; and N° 3, to 18 guns; and all under of N° 4. It is bent at the head to the ſprit-ſail-yard, extending within nine inches of the cleats on the yard-arms.

Guns - - - - -	110	98	80	74	50	44	38	36	24	18	16
Tons - - - - -	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the — head -	30	28	29	29	25	25	25	24	19	17	17
Number of cloths in the — foot -	30	28	29	29	25	25	25	24	19	17	17
Depth in yards - - -	9	9	$8\frac{1}{2}$	$8\frac{1}{2}$	7	$6\frac{1}{2}$	6	6	$5\frac{1}{2}$	5	5
Yards in the ſail - - -	270	252	$246\frac{1}{2}$	$246\frac{1}{2}$	175	$162\frac{1}{2}$	150	144	$104\frac{1}{2}$	85	85
——— reef-bands -	$9\frac{1}{2}$	$8\frac{3}{4}$	9	9	8	8	8	7	6	5	5
Totals -	$279\frac{1}{2}$	$260\frac{1}{2}$	$255\frac{1}{2}$	$255\frac{1}{2}$	183	$170\frac{1}{2}$	158	151	$110\frac{1}{2}$	90	90
	Inches.										
Bolt-rope on the — head -	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$
Bolt-rope on the — foot -	$3\frac{1}{4}$	$3\frac{1}{4}$	3	3	$2\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	2	$1\frac{3}{4}$	$1\frac{3}{4}$
Bolt-rope on the — leeches -	$3\frac{1}{4}$	$3\frac{1}{4}$	3	3	$2\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$	2	$1\frac{3}{4}$	$1\frac{3}{4}$

For *ſeams, tablings, reef* and *head-holes,* conſult the two firſt proceſſes of ſail-making.

Two *reef-bands,* one-third of the breadth of a cloth, are ſewed on diagonally; the ends on the leeches being 27 inches from the clues, and thoſe at the head on the ſecond or third ſeam from the earings. Sometimes a reef-band is ſewed on from leech to leech, at one-fifth of the depth of the ſail from the head.

A *water-hole,* from four to ſix inches diameter, is made in the ſecond cloth from each leech, near the foot, or oppoſite the reef-cringles.

Marline-holes extend two feet each way from the clues.

Bolt-rope and *clues,* and ſewing them on, conſult the third proceſs in ſail-making.

A reef-cringle is made on the leeches at the end of each reef-band, and two buntline-cringles are made on the foot-rope, at one-third of the breadth of the foot from each clue.

To find the quantity of canvas, refer to Rule 3.

MAIN-TOPSAIL, 2. *Plate* IV. *fig.* 2.

This ſail is quadrilateral, ſquare on the head and foot in the navy, and made of canvas N° 2, from 50 guns and upwards; and N° 3, all under. It is bent at the head to the main-topſail-yard, and extends within eighteen inches of the cleats on the yard-arms, and drops to the main-yard when the reſpective yards are hoiſted to the hounds.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutt.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the head	31	30	31	31	26	26	25	24	20	18	17	13	23
Number of cloths in the foot	49	48	48	48	40	40	40	38	32	29	28	19½	27
Depth in yards	21	20	20¼	20¼	16¼	16¾	16½	16¼	13¾	13	12	9¾	13¾
Yards in the ſail	840	780	799⅞	799⅞	536¼	544¾	536¼	503¾	357½	305½	270	158¼	362
——— reef-bands	56	53	54	54	34	34	33	32	27½	27	25	9½	10
——— middle band	27	25	26	26	21½	22	22	21¾	17½	14½	14	2¾	Gores.
——— leech-linings	44	42½	42⅝	42⅝	34½	35	34	34	26	25	25	20½	6
——— top-lining	75	74	70	70	55¾	54	53	53	37½	28	26½	15	14
——— buntline-cloths	12	12	12	12	10	10¼	9¾	9¾	8¼	6¾	6½	11	
Totals	1054	986½	1004½	1004½	692	700	688	654¼	474¼	406¾	367	217	392
	Inches.												
Bolt-rope on the head	2½	2¼	2¼	2¼	2	2	2	1¾	1½	1½	1½	1½	1½
Bolt-rope on the foot	5¾	5½	5½	5½	5	5	5	4¼	3¾	3	3	2¼	2¼
Bolt-rope on the leeches	5	4¾	4¾	4¾	4¼	4¼	4¼	3½	3	2½	2½	2¼	2¼

Gores.—The cloths on the leeches are gored ſufficiently for the foot to ſpread the cleats on the arms of the main-yard. In merchant-ſhips the *foot* is gored from two to four inches *per* cloth, one-third of the breadth of the foot from the clues.

For *ſeams*, *tablings*, *reef* and *head-holes*, refer to the firſt proceſs in ſail-making.

Reef-bands.—This ſail has moſtly four reef-bands of N° 2 cloth, from 50 guns upwards; N° 3 to 18; and N° 4 for 16 guns; put on at one-eighth of the ſail aſunder, the upper one being kept at that diſtance from the head. In merchant-ſhips the reef-bands are moſtly put on farther diſtant from each other.

Middle band is of N° 5 cloth, from 74 guns upwards; N° 6 to 18; and N° 7 for 16 guns; put on half-way between the lower reef-band and the foot.

Leech-lining is of N° 2 cloth, from 50 guns upwards; N° 3 to 18; and N° 4 for 16 guns. (See firſt proceſs of ſail-making.) Merchant-ſhips have leech-linings nine inches broad at the head, and fifteen inches broad at the foot.

Top-lining of N° 6 cloth, from 18 guns upwards, and N° 7 for 16 guns; covers one-fifth of the cloths on the aft-ſide of the *foot* in the middle of the ſail. In merchant-ſhips the top-lining covers one-third of the cloths in the foot.

Two *maſt-cloths* are put on in the middle of the ſail, on the aft-ſide, between the middle band and lower reef-band.

Two *buntline-cloths* (the ſame N° of cloth as the leech-lining) are put on the fore-ſide of the ſail, and one each ſide of the top-lining; their ends are carried up under the middle band, which is tabled on them. In merchant-ſhips the buntline-cloths are half a yard ſhorter than the top-linings.

Bolt-rope.—Three inches of *ſlack-cloth* are taken up in ſewing on the bolt-rope in every cloth on the head and foot; two inches are allowed for every cloth left open in the top-brim; and one inch and a half is taken up in every yard in the leeches. The bolt-rope along the top-brim, and for one cloth and a half on each ſide beyond, is wormed, parcelled, and ſerved as the clues, and is marled to the ſail; but ſometimes the whole length of the foot-rope, from clue to clue, is wormed, parcelled, &c. See third proceſs in ſail-making.

Clues.—The clues are made of the foot-rope, which is left ſufficiently long for that purpoſe, and ſplice into the leech-rope at the lower bowline-cringle. It is wormed, parcelled, and ſerved at the clues, and three feet each way from them: it is marled on to the ſail the extent of the ſerving on each ſide of the clues, which are ſeized as thoſe of the main-courſe.

The *marline-holes* extend three feet each way from the clues, and along the breadth of the top-lining at the top-brim.

Cringles.—One *reef-cringle* is made on the leeches at the end of each reef-band, and a *reef-tackle-pendant-cringle* between the lower reef and upper bowline-cringle; below theſe are four *bowline-cringles;* the upper one is in the middle of the leech, and the other three are equally diſtant from each other between the upper one and the clue. One *buntline-cringle* is made in the middle of each buntline-cloth at the foot. In merchant-ſhips three bowline-cringles only are made on the leeches.

To find the quantity of canvas contained in this ſail, refer to Rule 1.

Fore-topsail, 6. *Plate* IV. *fig.* 2.

This fail is quadrilateral, fquare on the head and foot in the royal navy, and made of canvas, the fame as the main-topfail. The head is bent to the fore-topfail-yard, extending at the head within 18 inches of the cleats on the yard-arms.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the head	27	26	28	28	22	22	22	22	17	16	15	13
Number of cloths in the foot	43	41	42	42	35	34	34	33	28	25	24	19½
Depth in yards	19	18	18½	18	14¾	14¾	14½	14¼	12¼	11¾	10½	9½
Yards in the fail	665	603	647½	630	420⅛	413	406	391½	276⅝	240⅞	204½	154⅜
—— reef-band	45	41	46	46	30	30	30	29½	23	22	21	9
—— middle band	23	22	23	23	19	19	19	19	15	13½	12⅛	Gores. 2⅝
—— leech-linings	40	38	39	38	31½	31½	30½	30	25½	24½	21½	20
—— top-linings	58	56	57	56	40¾	40	39	39	30½	27	23½	16
—— buntline-cloths	10½	10½	10	9½	9	9	8½	8½	7½	6½	6	9½
Totals	841½	770½	822½	802½	550⅝	542½	533	517½	378⅛	334⅜	288⅛	212⅓
	Inches.											
Bolt-rope on the head	2	2	2	2	1½	1½	1½	1½	1½	1¼	1¼	1½
Bolt-rope on the foot	5¼	5	5	5	4	4	4	3¾	3¼	2¾	2¾	2¼
Bolt-rope on the leeches	4½	4¼	4¼	4¼	3¼	3¼	3¼	3	3	2¾	2¼	2¼

Gores, and every other particular, the fame as the main-topfail.

Mizen-topsail, 10. *Plate* IV. *fig.* 2.

This fail is quadrilateral, cut fquare on the head, and made of canvas N° 4, from 50-gun fhips and upwards, N° 5 to 18 guns; and of N° 6, thofe of 16 guns. It is bent at the head to the mizen-topfail-yard, and drops to the crofs-jack-yard, extending within twelve inches of the cleats on the yard-arms.

Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head	21	20½		21	17	18	18	17	13½	12	12
Number of cloths in the foot	31	29	30	30	25½	25½	25½	25	20	18	17½
Depth in yards	14½	13¾	14¼	14			11¾	11¼	9¼		7¾
Yards in the fail	377	340	363¼	357	233¾	255½	255	236¼	155		113¾
—— reef-bands	21	20½	21	21	20¼	20½	20½	18¾	9½		8½
—— middle band	16¾	16	16	16	15¾	16	16	15	11		9½
—— leech-linings	31½	30½	31¼	31	27½	28	28	26	21		18½
—— top-lining	38½	37¾	38	38	33	34	34	32	18½		14
—— buntline-cloths	8¼	8¼	8¼		6¾	7	7	7	6		4½
gores	4	4	4		4	4	4	4	4		4
Totals	497	457	481¾	475	341	365	365	339	225	175¼	172¾
	Inches.										
Bolt-rope on the head	1½				1½	1½	1½	1½	1¼	1¼	1¼
Bolt-rope on the foot	3½			3½	3	3	3	3	2¾	2¼	2¼
Bolt-rope on the leeches				2¼	2½	2½	2½	2½	2¼	1¾	1¾

Gores.—The cloths on the leeches are gored fufficiently for the foot to fpread to the cleats on the arms of the crofs-jack-yard. The gore on the foot is three-quarters of a yard deep, and begins at two cloths from the buntline-cringle, on the fide next the clues. In merchant-fhips the foot is fometimes fquare.

For *feams, &c.* fee MAIN-TOPSAIL.

Reef-bands.—For 36-gun fhips and upwards, to have three reef-bands of N° 4 canvas, at one-eighth of the depth of the fail afunder from the head; and 24-gun fhips and under of the fame canvas the fail is made of, and two reefs only one-feventh of the depth of the fail afunder. Merchant-fhips have feldom more than two reef-bands.

Middle band, of N° 6 canvas, for 36-gun fhips and upwards; and N° 7 all under, put on as main-topfail. Merchant-fhips have none.

Leech-linings, &c. &c. fimilar to the main-topfail.

MAIN-TOPGALLANT-SAIL, 3. *Plate* IV. *fig.* 2.

This fail is quadrilateral, and fquare on the head and foot, in the royal navy, and made of canvas N° 6, from 50-gun fhips upwards; and all fhips under, of N° 7. The head is bent to the main-topgallant-yard, and extends within fix inches of the cleats on the yard-arms.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutter.
Tons	2165	1970	1900	1860	1200	1120	1140	920	600	425	360	200	180
Number of cloths in the head	23	21	22	22	18	18	18	16	14	13	12	10½	7
Number of cloths in the foot	31	30	31	31	27	26	26	25	21	19	18	14	17
Depth in yards	10½	10	10	10	8	8¼	8¼	7¾	6¾	6½	6	5½	6½
Yards in the fail	283½	255	265	265	180	181½	181½	159	117¾	104	90	70½	78
Yards in the clue and earing-pieces	3	3	3	3	3	3	3	3	3	3	3	2½	3
Totals	286½	258	268	268	183	184½	184½	162	120¾	107	93	73	81
Bolt-rope on the head (Inches.)	1½	1½	1½	1½	1¼	1¼	1¼	1¼	1¼	1	1	1	1
Bolt-rope on the foot	2¾	2¾	2¾	2¾	2¼	2¼	2¼	2¼	2	1¾	1½	1½	1½
Bolt-rope on the leeches	2¾	2¾	2¾	2¾	2¼	2¼	2¼	2¼	2	1¾	1½	1½	1½

Gores.—The cloths on the leeches are gored fufficiently for the foot to fpread to the cleats on the arms of the main-topfail-yard. A gore of two or three inches *per* cloth is often made on the foot, in merchant-fhips, beginning at one-third of the breadth of the foot from the clue.

For *feams, tablings, head-holes, fewing on the bolt-rope,* and *clues,* refer to the three proceffes of fail-making.

The cloth at the clue is fo cut as to fall to the foot, and form its own *lining;* and earing-pieces, of a quarter of a yard, are put on each corner, at the head.

Three *bowline-cringles* are made on each leech, the upper one in the middle, and the others equally afunder between that and the clue.

To find the quantity of canvas, refer to Rule 1.

FORE-TOPGALLANT-SAIL, 7. *Plate* IV. *fig.* 2.

This fail bends at the head to the fore-topgallant-yard, and is fo much like the former as only to need the following dimenfions.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the head	20	19	19	19	15	15	15	14½	12	11	10½	10½
Number of cloths in the foot	28	26	27	27	24	23	23	22½	18	17	16	14
Depth in yards	10	9	8½	8½	7½	7¼	7¼	6¾	6	6	5½	5½
Yards in the fail	240	202½	195½	195½	146¼	137¾	137¾	125	90	84	73¼	70½
Yards in the clue and earing-pieces	3	3	3	3	3	3	3	3	3	3	3	2½
Totals	243	205½	198½	198½	149¼	140¾	140¾	128	93	87	76¼	73
Bolt-rope as the main-topgallant-fail.												

Mizen-topgallant-sail, 11. *Plate* IV. *fig.* 2.

This fail is quadrilateral, fquare on the head and foot, in the navy; made of canvas N° 7, from 50-gun fhips upwards, and all under of N° 8. The head bends to the mizen-topgallant-yard, extending within fix inches on the cleats on the yard-arms.

Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head	15	15	15	15	12½	13	13	12½	10½	8	8
Number of cloths in the foot	22	21	21	21	17½	19	19	18	14	13	12
Depth in yards	7	7	7	7	6¼	6¼	6¼	6¼	5	4½	4½
Yards in the fail	129½	126	126	126	93¾	100	100	95⅛	61¼	47¼	45
Yards in the clue and earing-pieces	1	1	1	1	1	1	1	1	1	1	1
Totals	130½	127	127	127	94¾	101	101	96⅛	62¼	48¼	46
	Inches.										
Bolt-rope on the head	1¼	1¼	1¼	1¼	1	1	1	1	1	1	1
Bolt-rope on the foot	2	2	2	2	1½	1½	1½	1½	1¼	1¼	1¼
Bolt-rope on the leeches	2	2	2	2	1½	1½	1½	1½	1¼	1¼	1¼

Gores.—The leeches are gored fufficiently for the foot to fpread to the cleats on the arms of the mizen-topfail-yard. In merchant-fhips a fmall gore is fometimes made on the foot, beginning at one-third of the breadth from the clue.

Pieces, at the clues and earings, are each a quarter of a yard in length.

For the *feams*, *tablings*, *head-holes*, *clues*, and *bolt-rope*, confult the three proceffes of fail-making.

To find the quantity of canvas, refer to Rule 1.

Main-royal, 4. *Plate* IV. *fig.* 2.

This fail is quadrilateral, fquare on the head and foot, made of canvas N° 8. The head is bent to the main-royal-yard, and extends within four inches of the cleats on the yard-arms.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the head	16	15	14	14	11½	11	11	11	9½	9	8	7½
Number of cloths in the foot	23	22	21	21	18	17	17	16	13½	13	12½	11
Depth in yards	8	7½	7	7	6	6¼	6¼	6¼	4¾	4	3¾	4
Yards in the fail	156	138¾	121½	121½	88½	87½	87½	84¾	54⅛	44	38½	37
	Inches.											
Bolt-rope on the head	1¼	1¼	1¼	1¼	1	1	1	1	1	1	1	1
Bolt-rope on the foot	2	2	1¾	1¾	1½	1½	1½	1½	1¼	1¼	1¼	1¼
Bolt-rope on the leeches	2	2	1¾	1¾	1½	1½	1½	1½	1¼	1¼	1¼	1¼

Gores.—The cloths on the leeches are gored fufficiently for the foot to fpread to the cleats on the main-topgallant-yard-arms.

For *feams*, *tablings*, *head-holes*, and *clues*, confult the three proceffes in fail-making.

To find the quantity of canvas, refer to Rule 1.

Fore-royal, 8. *Plate* IV. *fig.* 2.

This fail is bent at the head to the fore-royal-yard, and is fo much like the former, as only to need the following dimenfions.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the head	13	12	12	12	10	10	10	10	8½	8	7½	7½
Number of cloths in the foot	20	19	19	19	15	15	15	15	12½	11½	11	11
Depth in yards	7	6¾	6¾	6¾	5	5	5	5	4½	3¾	3½	4
Yards in the fail	115½	104⅝	104⅝	104⅝	62½	62½	62½	62½	47¼	36¾	32⅛	37
Bolt-rope the fame fize as the main-royal.												

Mizen-royal, 12. *Plate* IV. *fig.* 2.

This fail is bent at the head to the mizen-royal-yard, and fo like the main-royal, as only to need the following dimenfions.

Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head	11	11	11	11	9	9	9	9	7	4	4
Number of cloths in the foot	15	15	15	15	13	13	13	13	11	8	8
Depth in yards	5½	5½	5½	5½	4¾	4¾	4¾	4¾	3¼	3¼	3
Yards in the fail	71½	71½	71½	71½	52¼	52¼	52¼	52¼	29¼	19½	18
	Inches.										
Bolt-rope on the head	1	1	1	1	1	1	1	1	¾	¾	¾
Bolt-rope on the foot	1¾	1¾	1¾	1¾	1¼	1¼	1¼	1¼	1	1	1
Bolt-rope on the leeches	1¾	1¾	1¾	1¾	1¼	1¼	1¼	1¼	1	1	1

Main-staysail, 1. *Plate* IV. *fig.* 1.

This fail is triangular, fquare on the foot in the royal navy, and made of canvas N° 1, from 50-gun fhips upwards, N° 2 to 18 guns, and all under of N° 3. It is extended upon the main-ftayfail-ftay, and drops to clear the foot of the boats upon the beams. This fail is feldom ufed in large veffels.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the foot	32	31	32	32	26	25	24	24	22	18	17	head 13, foot 14
Depth in yards	15	14	16	16	13	13½	13¼	13	11½	9½	9½	9
Yards in the fail	240	217	256	256	169	168¾	159	156	126½	85½	80¾	67½
Yards in the tack and peek-pieces	2	2	2	2	2	2	2	2	2	2	2	1
Yards in the clue-piece	2	2	2	2	2	2	2	2	2	2	2	1½
Totals	244	221	260	260	173	172¾	163	160	130½	89½	84¾	70
	Inches.											
Bolt-rope on the head	3¼	3¼	3	3	2¾	2¾	2½	2½	2¼	2	2	2
Bolt-rope on the foot	3¼	3¼	3	3	2¾	2¾	2½	2½	2¼	2	2	2
Bolt-rope on the after-leech	3¼	3¼	3	3	2¾	2¾	2½	2½	2¼	2	2	2

Gores.—A regular gore is made on the head, of from 17 to 19 inches *per* cloth; the depth of the gore on each cloth in the head, is found by dividing the depth of the leech by the number of cloths. The cloth at the tack is ſo cut as to fall to the foot, and form its own *lining*. The *clue-piece* extends two yards up the leech, and the *peek-piece* is one yard in length.

For *ſeams, tablings, holes, ſewing on the bolt-rope,* and *clue,* conſult the three proceſſes in ſail-making.

Iron thimbles are ſometimes ſtuck at the tack and peek; butwhen none, the tack and peek are the ſame as the clue.

A *cringle* is made on the leech for the brails, but is uſually done by the ſeamen on board.

In merchant-ſhips this ſail is frequently cut with a bunt, and a gore is ſometimes made on the foot, with a ſweep. It alſo frequently has a reef-band at about four feet from the foot, and ſometimes a bonnet.

To find the quantity of canvas, refer to Rule 5.

Fore-staysail, 5. *Plate* IV. *fig.* 1.

This ſail is triangular, ſquare on the foot, and made of canvas N° 1, from 50-gun ſhips upwards, N° 2 to 18 guns, and all under of N° 3. It is extended on the fore-ſtay or fore-preventer-ſtay.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the foot	23	22	22	22	18	17	17	17	15	14	13	9
Depth in yards	13	12	$13\frac{1}{4}$	$13\frac{1}{4}$	11	$11\frac{1}{4}$	11	11	$9\frac{1}{2}$	$8\frac{1}{2}$	8	9
Yards in the ſail	$149\frac{1}{2}$	132	$145\frac{3}{4}$	$145\frac{3}{4}$	99	$95\frac{5}{8}$	$93\frac{1}{2}$	$93\frac{1}{2}$	$71\frac{1}{4}$	$59\frac{1}{2}$	52	$40\frac{1}{2}$
Yards in the tack and peek-pieces	1	1	1	1	1	1	1	1	1	1	1	3
Yards in the clue-piece	2	2	2	2	2	2	2	2	2	2	2	
Totals	$152\frac{1}{2}$	135	$148\frac{3}{4}$	$148\frac{3}{4}$	102	$98\frac{5}{8}$	$96\frac{1}{2}$	$96\frac{1}{2}$	$74\frac{1}{4}$	$62\frac{1}{2}$	55	$43\frac{1}{2}$
Bolt-rope as the main-ſtay-ſail.												

Gores.—A regular gore is made on the ſtay or head, of from 21 to 23 inches *per* cloth. The remainder of this ſail is ſo much like the former as to need no further deſcription.

Fore-topmast-staysail, 6. *Plate* IV. *fig.* 1.

This ſail is triangular, cut ſquare on the foot, and made of canvas N° 5, from 50-gun ſhips upwards, and all under of N° 6. It is hoiſted on the fore-topmaſt-ſtayſail-ſtay. The leech is generally the ſame depth as the fore-topſail. In merchant-ſhips, one cloth only is allowed in the foot for every yard in the depth of the leech.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the foot	22	21	21	21	17	16	16	16	14	13	12	10
Depth in yards	19	18	18	18	15	15	$14\frac{1}{2}$	14	$12\frac{1}{2}$	$11\frac{1}{2}$	11	10
Yards in the ſail	209	189	189	189	$127\frac{1}{2}$	120	116	112	$87\frac{1}{2}$	$74\frac{3}{4}$	66	50
Yards in the tack and peek-pieces	2	2	2	2	2	2	2	2	1	1	1	3
Yards in the clue-piece	2	2	2	2	2	2	2	2	2	2	2	
Totals	213	193	193	193	$131\frac{1}{2}$	124	120	116	$90\frac{1}{2}$	$77\frac{3}{4}$	69	53
	Inches.											
Bolt-rope on the head	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	2	2	2	2
Bolt-rope on the foot	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	2	2	2	2
Bolt-rope on the after-leech	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	2	2	2	2

Gores.—The ſtay or head is gored 30 inches *per* cloth. For *ſeams, tablings,* &c. &c. refer to the main-ſtayſail.

JIB, 7. *Plate* IV. *fig.* 1.

This ſail is triangular, made of canvas N° 6, from ſhips of 50 guns and upwards, and all under of N° 7. It is hoiſted on the jib-ſtay. The leech is about twice the depth of the leech of the fore-ſtayſail, and one cloth more is allowed for the breadth of the foot than the leech is yards in depth.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutter.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the foot	27	26	26	26	23	22	22	21	19	17	16	12	22
Depth in yards	26	25	25	25	22	21	21	20	18	16	15	13	20
Yards in the ſail	351	325	325	325	253	231	231	210	171	136	120	78	230
Yards in the gores on the foot	28	24	24	24	17	13	13	12	11½	7	6¼	8	66
Yards in the clue, peek, and tack-pieces	3	3	3	3	3	3	3	3	3	3	3	3	6
Totals	382	352	352	352	273	247	247	225	185½	146	129¼	89	302
	Inches.												
Bolt-rope on the head or ſtay	3½	3¼	3¼	3¼	3	2¾	2¾	2¾	2½	2¼	2¼	2¼	6
Bolt-rope on the after-leech	1¾	1¾	1¾	1¾	1½	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½
Bolt-rope on the foot	1¾	1¾	1¾	1¾	1½	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½

Gores.—The head or ſtay is cut with a ſmall curve, or roach. The gores ſhould be allowed full, and the curve cut fair, after the ſail is ſewed together; which, it is ſuppoſed, makes it ſit better, when bent. The foot has an even gore of three inches *per* cloth, decreaſing from the tack to the clue, which is governed by the ſtive of the bowſprit.

For brigs, this ſail has a curve on the foot, and ſometimes in merchant-ſhips. The ſeams are generally one inch broader at the foot than at the head, when cut with a curve or roach-foot.

For *ſeams*, *tablings*, &c. &c. refer to the main-ſtay-ſail.

FLYING JIB.

This ſail is made of canvas N° 8, and ſo ſimilar to the former, as only to need the following dimenſions.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutter.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the foot	16	15	16	16	14	13	13	13	11	9	9	9	10
Depth in yards	20	19	20	20	17	15	15	15	14	11	11	11	10
Yards in the ſail	160	142½	160	160	119	97½	97½	97½	77	49½	49½	49½	50
Yards in the gores on the foot	19	17½	19	19	15	15	15	15	12	9	9	9	24
Yards in the clue, peek, and tack-pieces	3	3	3	3	3	3	3	3	3	3	3	3	6
Totals	182	163	182	182	137	115½	115½	115½	92	61½	61½	61½	80

MIZEN-STAYSAIL, 8. *Plate* IV. *fig.* 1.

This ſail is quadrilateral, cut ſquare on the foot, and made of canvas N° 2, from ſhips of 50 guns and upwards; N° 3, to 24-gun ſhips; and all under, N° 4. It is extended on the mizen-ſtay, and has a bunt, or fore-leech, three-fifths of the depth of the after-leech in the navy, and one-third or one-fourth of the depth of the after-leech in merchant-ſhips. The foot drops within ſix or ſeven feet of the quarter-deck.

Guns - - - - -	110	98	80	74	50	44	38	36	24	18	16
Tons - - - - -	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head -	23	21	21	20½	18	16½	16	16	14	13	13
Number of cloths in the foot -	25	23	23	22½	20	18½	18	18	16	15	15
Depth in yards of the after-leech	14	13	13½	13½	11	12½	12	12	9½	9	9
Depth in yards of the fore-leech	8½	8	9½	9½	7	7½	7	7	5½	5	5
Yards in the ſail - - -	270	231	247½	247¼	171	170½	161½	161½	112	87½	87½
Yards in the peek and clue-pieces - - - -	3	3	3	3	3	3	3	3	3	3	3
Yards in the bunt-lining -	4½	4	4¾	4¾	3½	4	3½	3½	2¾	2½	2½
Totals -	277½	238	255¼	255	177½	177½	168	168	117¾	93	93
	Inches.										
Bolt-rope on the head -	3¼	3¼	3¼	3¼	3	3	2¾	2¾	2½	2¼	2¼
Bolt-rope on the foot -	3¼	3¼	3¼	3¼	3	3	2¾	2¾	2½	2¼	2¼
Bolt-rope on the leeches -	3¼	3¼	3¼	3¼	3	3	2¾	2¾	2½	2¼	2¼

Gores.—Two cloths are generally gored on the bunt, and the head or ſtay is gored from 10 to 12 inches *per* cloth. If the depth of the bunt be ſubtracted from the depth of the leech; the remainder, divided by the number of cloths on the head, gives the depth of each gore on the ſtay.

For *ſeams* and *tablings*, conſult the firſt proceſs in ſail-making.

Linings, &c.—The bunt is lined with half a breadth of cloth; the *clue-piece* is two yards long, and the *peek-piece* one yard. In merchant-ſhips the tack, peek, and nock-pieces, are generally but three-quarters of a yard in length.

Cringles.—One or two are made on the after-leech for the brails, and thimbles are ſtuck in the middle of the ſail, to lead them through; but this is uſually done by the ſeamen on board.

Holes on the ſtay, *marline-holes* at the *clue*, and *ſewing on the bolt-rope*, as directed in the third proceſs of ſail-making.

Thimbles are ſometimes ſtuck at the tack and peek; but when thimbles are not uſed, the tack and peek are frequently marled as the clue.

To find the quantity of canvas, refer to Rule 6.

Main-topmast-staysail, 12. *Plate* IV. *fig.* 1.

This ſail is quadrilateral, cut ſquare on the foot, and made of canvas N° 5, from ſhips of 50 guns and upwards; and of N° 6, all under. It hoiſts on the main-topmaſt-preventer-ſtay. The leech is four or five yards deeper than the main-topſail, and there are one or two cloths more in the foot than the leech is yards in depth. In large merchant-ſhips, the leech is four or five yards deeper than the main-topſail; but in ſmaller ſhips, only one or two cloths more in the foot than the leech is yards in depth.

The bunt is two-fifths of the depth of the leech; but in merchant-ſhips, it is from two-fifths to one-half of the depth.

Guns		110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons		2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the	head	26	25	25	25	21	20	19½	19½	17	15	14	12
	foot	28	27	27	27	23	22	21½	21½	19	17	16	13
Depth in yards of the	after-leech	26	25	25	25	21¾	21	20½	20½	18	16	15½	11
	fore-leech	10	9	9½	9½	8¾	8½	8	8	7	6	5½	5
Yards in the ſail		486	442	448½	448½	335½	309¾	292⅛	292⅛	234	176	157½	106¼
Yards in the peek and clue-pieces		3	3	3	3	3	3	3	3	3	3	3	3
Yards in the bunt-lining		5	4½	5	5	4½	4	4	4	3½	3	2¾	2½
Totals		494	449½	456½	456½	343	316¾	299⅛	299⅛	240½	182	163¼	111¾
		Inches.											
Bolt-rope on the	head or ſtay	3½	3½	3½	3½	2¾	2½	2½	2½	2¼	2	2	2
	foot	2	2	2	2	1¾	1½	1½	1½	1½	1¼	1¼	1¼
	leeches	2	2	2	2	1¾	1½	1½	1½	1½	1¼	1¼	1¼

Gores.—Two cloths are generally gored on the bunt, and the head is gored 22 inches *per* cloth. If the nock-ſeam be ſubtracted from the depth of the leech, the remainder, divided by the number of cloths on the head, gives the depth of each gore.

Seams, tablings, cringles, &c. &c. as the mizen-ſtayſail.

Mizen-topmast-staysail, 9. *Plate* IV. *fig.* 1.

This ſail is quadrilateral, cut ſquare on the foot, and made of canvas N° 6, from 50 guns upwards; and N° 7, all under. It has a bunt, or fore-leech, three-ſevenths or one-third of the depth of the after-leech, and is hoiſted on the mizen-topmaſt-ſtay. The after-leech is one or two yards deeper than the mizen-topſail, and there are from two to five cloths more in the foot than the leech is yards in depth.

Guns		110	98	80	74	50	44	38	36	24	18	16
Tons		2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the	head	20	19	19	19	15	13½	13	13	11	9	9
	foot	21	20	20	20	16	14½	14	14	12	10	10
Depth in yards of the	after-leech	16	14½	16	15½	13	12½	12	12	10½	9½	9½
	fore-leech	7	6½	7	6½	4½	4½	4	4	3	3	3
Yards in the ſail		235¾	204¾	224¼	214½	135⅝	119	108	108	77⅝	59½	59½
Yards in the peek and clue-pieces		3	3	3	3	3	3	3	3	3	3	3
Yards in the bunt-lining		3½	3¼	3½	3¼	2¼	2¼	2	2	1½	1½	1½
Totals		242¼	211	230¾	220¾	140⅞	124¼	113	113	82⅛	64	64
		Inches.										
Bolt-rope on the	head	2¾	2¾	2½	2½	2¼	2¼	2¼	2¼	2	1¾	1¾
	foot	1¾	1¾	1½	1½	1½	1½	1½	1½	1¼	1¼	1¼
	leeches	1¾	1¼	1½	1½	1½	1½	1½	1½	1¼	1¼	1¼

Gores.—One cloth is generally gored on the bunt, and the head is gored 24 inches *per* cloth.

Seams, tablings, &c. &c. as the mizen-ſtayſail.

Middle Staysail, 3. *Plate* IV. *fig.* 1.

This fail is quadrilateral, cut fquare on the foot, and made of canvas N° 6, from 50 guns and upwards; and N° 7, all under. It has a fquare bunt, or fore-leech, five-twelfths of the depth of the after-leech, and is hoifted on the middle ftayfail-ftay. The leech is from four to feven yards deeper than the main-topgallant-fail, and there are from fix to eight cloths more in the foot than the after-leech is yards in depth. Sloops and brigs in the royal navy have only from one to three cloths more in the foot than yards in the depth of the after-leech. In merchant-fhips, the leech is fometimes of the fame depth as the main-topgallant-fail, but generally one to three yards more; and has from five to ten cloths more in the foot than yards in the depth of the after-leech.

Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head	25	24	24	24	20	19	18	18	16	14	13
Number of cloths in the foot	25	24	24	24	20	19	18	18	16	14	13
Depth in yards of the after-leech	17	16½	16½	16½	13	13	12	12	10¾	10	10
Depth in yards of the bunt or fore-leech	8	7½	7½	7½	5½	5½	5	5	4¼	4	4
Yards in the fail	312½	288	288	288	185	175¾	153	153	120	98	91
Yards in the clue and peek-pieces	3	3	3	3	3	3	3	3	3	3	3
Yards in the bunt-lining	4	3¾	3¾	3¾	2¾	2¾	2½	2½	2⅛	2	2
Totals	319½	294¾	294¾	294¾	190¾	181½	158½	158½	125⅛	103	96
	Inches.										
Bolt-rope on the head or ftay	3¼	3	3	3	2½	2½	2½	2½	2	1¾	1¾
Bolt-rope on the foot	1¾	1¾	1¾	1¾	1½	1½	1½	1½	1¼	1¼	1½
Bolt-rope on the leeches	1¾	1¾	1¾	1¾	1½	1½	1½	1½	1¼	1¼	1¼

Gores. The head is gored 13½ inches *per* cloth. *Seams, tablings,* &c. &c. as the above.

Main-topgallant-staysail, 4. *Plate* IV. *fig.* 1.

This fail is quadrilateral, cut fquare on the foot, and made of canvas N° 7, from 50 guns and upwards, and all under of N° 8. It has a bunt from one-third to three-fevenths of the depth of the after-leech, and is hoifted on the main-topgallant-ftayfail-ftay. The after-leech is nearly of the fame depth as the leech of the middle ftayfail, and there are from three to fix cloths more in the foot than the leech is yards in depth. In merchant-fhips there are from two to eight cloths more in the foot than the leech is yards in depth.

Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head or ftay	22	21	21	21	17	16	15	15	13	12	12
Number of cloths in the foot	22	21	21	21	17	16	15	15	13	12	12
Depth in yards of the after-leech	16½	15½	15½	15½	13½	12½	12	12	10¼	9½	9½
Depth in yards of the bunt or fore-leech	7	6	6½	6½	4½	4½	4	4	2¾	2½	2½
Yards in the fail	258½	225¾	231	231	153	136	120	120	84½	72	72
Yards in the clue and peek-pieces	3	3	3	3	3	3	3	3	3	3	3
Yards in the bunt-lining	3½	3	3¼	3¼	2¼	2¼	2	2	1½	1¼	1¼
Totals	265	231¾	237¼	237¼	158¼	141¼	125	125	89	76¼	76¼

Gores.—The head is gored 24 inches *per* yard. *Seams, tablings,* &c. &c. as the mizen-ftayfail.

DRIVER-BOOMSAIL, 11. *Plate* IV. *fig.* 1.

This fail is quadrilateral, made of canvas N° 6, and is occafionally hoifted to the gaff in light fair winds. The fore-leech laces to the mizen-maft, and the inner part of the head to the gaff, and the outer part to a fmall yard.

The fore-leech is nearly the fame depth as the fore-leech of the mizen-courfe, and the after-leech is from two to four yards deeper than the after-leech of the mizen-courfe.

	110	98	80	74	50	44	38	36	24	18	16
Guns	110	98	80	74	50	44	38	36	24	18	16
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360
Number of cloths in the head	25		26	25½	21	22½	22	19	16	15	14
Number of cloths in the foot	31		33	32½	27	28½	27	25	21	19	18
Depth in yards of the after-leech	22½		24	24	19	23	23	22	18	16	16
Depth in yards of the fore-leech	10		11	11	8½	11½	11½	11	8	8	7¾
Yards in the fail - - -	455	414⅜	515¾	507½	330	440	422⅝	363	222	204	189½
Yards in the clue-piece -	5	5	5	5	5	5	5	5	5	5	5
Yards in the tack, nock, and peek-pieces - -	3	3	3	3	3	3	3	3	3	3	3
Yards in the gores - -	56	52	65½	63	47	53	47	36	26	20½	18
Totals -	519	474⅜	589¼	578½	385	501	477⅝	407	256	232½	215½
	Inches.										
Bolt-rope on the head	1¾	1¾	1¾	1¾		1¾	1¾	1¾		1¼	1¼
Bolt-rope on the foot	3	3	3	3		3	3	2½		2	2
Bolt-rope on the leeches	3	3	3	3		3	3	2½		2	2

Gores.—The head, foot, and maft-leech are cut with a roach or curve; and as no ftrict rule can be laid down, the gores muft be judicioufly increafed or diminifhed, according to the fweep required. The gore on the head is at the rate of from nine to twelve inches *per* cloth; and on the foot from fix to nine inches *per* cloth. From four to fix cloths next the clue are cut fquare; or the fifth cloth next the clue being fquare, the other four cloths are fhort-gored, one inch *per* cloth to the clue. From four to fix cloths are gored on the maft-leech; and if the depth of the leech be divided by the number of cloths in it, the quotient will be the regular gore *per* cloth, which muft be ıncreafed on the middle cloths, fo as to form the fweep required.

Seams are fix inches broad for fix feet up the fail from the foot; and two inches broad for four feet down from the head: the remainder is one inch broad. The feams are to decreafe gradually from one breadth to the other, but the felvage is not cut.

Tablings and *head-holes*, fee fecond procefs in fail-making.

Clue-lining is five yards in length, and the *tack*, *nock*, and *peek-pieces* are each one yard in length.

Slack-cloth.—Two inches fhould be taken up with the rope in every yard on the maft-leech, and one inch in every cloth in the foot.

Iron thimbles are generally fpliced in the rope at the tack, nock, and peek, which are otherwife fitted as the mizen-courfe.

Clue likewife is fometimes made with an iron thimble; but if not, it is made as defcribed in the third procefs of fail-making.

Cringles for the lacing are made on the maft-leech, thirty inches afunder.

To find the quantity of canvas, refer to Rule 4.

Lower Main-studding-sails, 18. *Plate* IV. *fig.* 2.

Thefe fails are quadrilateral, cut fquare on the head, foot, and leeches, and made of canvas N° 6, from 50 guns upwards, and N° 7 all under. They are fpread beyond the leeches of the main-courfe, their heads being bent to their refpective yards.

Thefe fails are two or three yards deeper than the main-courfe. In large fhips, two cloths more, and in fmall fhips one cloth lefs, are allowed for the breadth, than the number of yards in the depth. But in merchant-fhips, they are only one yard deeper, or of the fame depth as the main-courfe; and from two to feven cloths are allowed in the foot more than the number of yards in the depth.

Guns - - - - -	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutter.
Tons - - - - -	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the - - head	20	19	19	19	16	16	15	15	12	11	11		10
Number of cloths in the - - foot	20	19	19	19	16	16	15	15	12	11	11		13
Depth in yards - -	17½	17	18½	18½	15½	15½	15¼	15¼	13	11	11		20
Yards in the fail - -	350	323	351½	351½	248	248	228¾	228¾	156	121	121		225
Yards in the reef-band -	3½	3¼	3¼	3¼	2⅞	2⅞	2½	2½	2	1¾	1¾		
Yards in the clue and earing-pieces - - - -	1	1	1	1	1	1	1	1	1	1	1		2
Totals -	354½	327¼	355¾	355¾	251⅞	251⅞	232¼	232¼	159	123¾	123¾		227
	Inches.												
Bolt-rope on the head -	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1	1		1¼
Bolt-rope on the foot	2¼	2¼	2¼	2¼	2	2	1¾	1¾	1¾	1½	1½		1¾
Bolt-rope on the leeches -	2¼	2¼	2¼	2¼	2	2	1¾	1¾	1¾	1½	1½		1¾

For *feams, tablings, reef* and *head-holes*, confult the two firft proceffes in fail-making.

A *reef-band*, fix inches wide, is put on at one-eighth of the depth from the head, and a *reef-cringle* made at each end of the reef-band.

Clues, earings, and *fewing on bolt-rope*, fee third procefs in fail-making.

To find the quantity of canvas, refer to Rule 3.

Lower Fore-studding-sail, 15. *Plate* IV. *fig.* 2.

This fail is like the former, except that it has no reef.

Guns - - - - -	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons - - - - -	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the - - head	19	18	18	18	15	15	14	14	11	10	10	10
Number of cloths in the - - foot	19	18	18	18	15	15	14	14	11	10	10	10
Depth in yards - -	14½	14	15	15	13	13	13	13	11	10	10	9
Yards in the fail - -	285½	252	270	270	195	195	182	182	121	100	100	90
Yards in the clue and earing-pieces - -	1	1	1	1	1	1	1	1	1	1	1	1
Totals -	286½	253	271	271	196	196	183	183	122	101	101	91
Bolt-rope the fame as main-lower-ftudding-fail.												

MAIN-TOPMAST-STUDDING-SAILS, 19. *Plate* IV. *fig.* 2.

Thefe fails are quadrilateral, and made of the fame canvas as the lower ftudding-fails. They are fpread beyond the leeches of the main-topfail.

The depth is one yard more than the main-topfail, and two cloths lefs are allowed for the breadth of the foot than the number of yards in the depth of the leech.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutter
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the head	16	15	15	15	12	11	11	11	8	8	8	8	8
Number of cloths in the foot	20	19	19	19	16	15	15	15	12	12	11	10	12
Depth in yards	22	21	$21\frac{1}{4}$	$21\frac{1}{4}$	$17\frac{1}{4}$	$17\frac{1}{2}$	$17\frac{1}{2}$	$17\frac{1}{4}$	$14\frac{1}{2}$	13	$12\frac{1}{2}$	$10\frac{1}{2}$	15
Yards in the fail	396	357	$361\frac{1}{4}$	$361\frac{1}{4}$	$241\frac{1}{2}$	$227\frac{1}{2}$	$227\frac{1}{2}$	$224\frac{1}{4}$	145	130	$118\frac{3}{4}$	$94\frac{1}{2}$	150
Yards in the reef-band	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	2	$1\frac{5}{8}$	$1\frac{5}{8}$	1 [illegible]	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$
Totals	$398\frac{3}{4}$	$359\frac{1}{2}$	$363\frac{3}{4}$	$363\frac{3}{4}$	$243\frac{1}{2}$	$229\frac{1}{8}$	$229\frac{1}{8}$	$226\frac{1}{8}$	$146\frac{1}{2}$	$131\frac{1}{2}$	$120\frac{1}{4}$	96	$151\frac{1}{2}$
Bolt-rope the fame fize as the main-lower-ftudding-fail.													

Gores.—Four cloths are gored on the outer leech in the royal navy, and from four to feven cloths in merchant-fhips; and a regular gore is made on the head and foot of four inches *per* cloth, decreafing to the outer earing at the head, and increafing to the tack or outer clue at the foot.

For *feams*, *tablings*, *reef* and *head-holes*, refer to the fecond procefs of fail-making.

Reef-band is put on the fame as the main-lower-ftudding-fail.

Reef-cringle, one is made on the leeches, at each end of the reef-band, and a *downhawl-cringle* is made on the outer leech, about half the depth of the leech from the head.

Clue and *fewing on the bolt-rope*, refer to the third procefs in fail-making.

To find the quantity of canvas, refer to Rule 1

FORE-TOPMAST-STUDDING-SAILS, 16. *Plate* IV. *fig.* 2.

Thefe fails are fo much like the former, *reef-bands* excepted, as only to need the following dimenfions.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the head	15	14	14	14	11	10	10	10	7	7	7	8
Number of cloths in the foot	19	18	18	18	15	14	14	14	11	11	10	10
Depth in yards	20	19	$18\frac{1}{2}$	$18\frac{1}{2}$	$15\frac{3}{4}$	$15\frac{1}{4}$	$15\frac{1}{4}$	$15\frac{1}{4}$	13	12	$11\frac{1}{2}$	$10\frac{1}{4}$
Yards in the fail	340	304	296	296	$204\frac{3}{4}$	183	183	183	117	108	$97\frac{3}{4}$	$92\frac{1}{4}$
Bolt-rope the fame fize as the main-topmaft-ftudding-fail.												

Main-topgallant-studding-sails, 20. *Plate* IV. *fig.* 2.

These sails are quadrilateral, and made of canvas N° 7, from 50-gun ships upwards, and all under of N° 8. They are spread beyond the leeches of the main-topgallant-sail, the heads being bent to their respective yards.

The depth is half a yard more than the main-topgallant-sail in large ships: there are five cloths more allowed for the breadth of the foot than the number of yards in the depth; but in small ships there are only three cloths more, or the same number of cloths in the breadth of the foot as yards in the depth of the leech.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.	Cutter
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200	180
Number of cloths in the — head	12	11		11	8	8	8	8	6	5		6	5
Number of cloths in the — foot	16	15	15	15	11	11	11	11	8	8		8	8
Depth in yards	11	10½	10½	10½	8	8¾	8¾	8¼	7¼	6¾	6½	6¼	7
Yards in the sail	154	136½	136½	136½	80¾	83⅛	83⅛	78⅜	50¾	43⅞	40⅝	43¾	45½
Bolt-rope on the — head (Inches)	1¼	1¼		1¼									
Bolt-rope on the — foot	2	2		2		1½	1½		1¼	1¼	1¼	1¼	1¼
Bolt-rope on the — leeches	2	2		2		1½	1½		1¼	1¼	1¼	1¼	1¼

Gores.—The outer leech is gored from two to four cloths, and a regular gore is made on the head and foot, from three to five inches *per* cloth, decreasing to the outer earing at the head, and increasing to the tack on the foot.

For *seams, tablings,* and *head-holes,* consult the first and second processes in sail-making.

Clues and *sewing on the bolt-rope,* see the third process in sail-making.

To find the quantity of canvas, refer to Rule 1.

Fore-topgallant-studding-sail, 17. *Plate* IV. *fig.* 2.

This sail is so much like the former, that the dimensions need only be added.

Guns	110	98	80	74	50	44	38	36	24	18	16	Brig.
Tons	2165	1970	1900	1860	1200	1120	1040	920	600	425	360	200
Number of cloths in the — head	11	10	10	10	7	7	7	7	5	4	4	6
Number of cloths in the — foot	15	14	14	14	10	10	10	10	7	7	7	8
Depth in yards	10	9¼	9½	9½	7¾	7¾	7¾	7¼	6½	6½	5¾	6¼
Yards in the sail	130	111	114	114	65⅞	65⅞	65⅞	61⅝	39	35¼	31⅛	43¾
Bolt-rope the same size as the main-top-gallant-studding-sail.												

Number of Sails in a Suit for eight Months' Service in the Royal Navy.

Two main-courses.
Two main-topsails.
One main-topgallant-sail.
One main-royal.
Two fore-courses.
Two fore-topsails.
Two fore-topgallant-sails.
One fore-royal.
One spritsail-course.
One spritsail-topsail.
One driver-boom-sail.
Two mizen-courses.
Two mizen-topsails.
One mizen-topgallant-sail.
One main-staysail.
Two fore-staysails.
One mizen-staysail.
Two main-topmast-staysails.
One middle-staysail.
One main-topgallant-staysail.
One fore-topmast-staysail.
One royal-staysail.
Two jibs.
One flying-jib.
One mizen-topmast-staysail.
Two main-studding-sails.
Two main-topmast-studding-sails.
Two main-topgallant-studding-sails.
Two fore-studding-sails.
Two fore-topmast-studding-sails.
One fore-topgallant-studding-sail.
One smoke-sail.

The Quality of Canvas of which the different Sails are made in the Merchant Service.

Canvas of N° 1.

Main and fore-courfes, and main and fore-ftayfails, of Eaft India fhips.

Canvas of N° 2.

Main and fore-courfes, and main and fore-ftayfails, of Weft India fhips.

Canvas of N° 3.

Mizen-courfe, main and fore-topfails, fprit-courfe, and mizen-ftayfails, of Eaft India fhips.

Canvas of N° 4.

Mizen-topfails of Eaft India fhips.

Canvas of N° 5.

Driver-boom-fails of large Eaft India fhips, main-topmaft-ftayfails of Eaft India fhips, and mizen-topfails of Weft India fhips.

Canvas of N° 6.

Driver-boom-fails of Eaft and Weft India fhips, fore-topmaft-ftayfails of Eaft India fhips, main-topmaft-ftayfails of Weft India fhips, fpritfail-topfails, and main and fore-top-gallant-fails, of large India fhips.

Canvas of N° 7.

Main and fore-topgallant-fails, middle-ftayfails, flying-jibs, lower ftudding-fail, main-topmaft-ftudding-fails, main-topgallant-ftayfail, of Eaft and Weft India fhips, and fore-topmaft-ftayfail of Weft India fhips.

Canvas of N° 8.

Mizen-topgallant-fails, and main-topgallant-ftudding-fails, of Eaft and Weft India fhips, mizen-topmaft-ftayfails and royals of Eaft India fhips, and fmall flying-jibs of Eaft India fhips, if any.

As there can be no fixed dimenfions of merchant-fhips' fails, the fame number of cloths, or nearly fo, of fhips of the fame tonnage in the royal navy may be taken, and about feven-eighths of their depth.

Quantity and Quality of Canvas of a fingle Suit of Sails for Eaft and Weft India Ships of London Canvas, thirty-eight Yards to the Bolt.

	Tons.	N° 1.	N° 2.	N° 3.	N° 4.	N° 5.	N° 6.	N° 7.	N° 8.	Total Number of Yards.
		Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
Eaft India fhips of	1200	1373	—	1788	306	744	835	1331	496	6873
	700	952½	—	1291	262	270	436	1384½	285½	4881½
Weft India fhips of	500	—	582½	714	—	151½	262¼	1010½	130	2851
	400	—	446	615	—	156	297	847½	156	2517½

A Table of the Quantity of Materials ufed in making a Suit of Sails for a Ship of each Rate for eight Months' Service in the Royal Navy, and a fingle Suit of Sails for Eaft and Weft India Ships.

	Guns.	Tons.	Old Canvas.	Twine Line. Extra, or fine.	Twine Line. Ordinary, or great.	Twine Line. Hambro.	Log.	Bees-Wax.	Rofin.	Turpentine.	Tallow.	Train-Oil.	Tar.	Spun-yarn.	Yards of fewing Twine. Waxed.	Yards of fewing Twine. Dipped.	Bolt-rope. Cwt.	qr.	lb.
			Yards.	Lb.	Lb.	No.	No.	Lb.	Lb.	Lb.	Lb.	Gall.	Barr.	Cwt.			Cwt.	qr.	lb.
Royal Navy of	110		100	340	170	43	21	56	50	14	122	39	6½	5½	42164	21822	32	2	24
	98		96	330	160	39	20	51	46	13	116	36	6	4¼	39554	20631	28	3	26
	80		96	336	165	42	21	56	48	14	121	36	6	5	41936	21018	29	0	21
	74		96	330	165	42	21	56	48	14	121	36	6	5	41711	20671	28	3	24
	50		70	250	120	37	17	40	36	10	90	21	3½	3¼	31264	14908	16	3	21
	44		70	246	118	36	16	39	34	10	88	20	3	3	31923	14150	14	3	22
	38		65	238	114	36	16	38	34	10	86	18	3	3	31173	13913	14	1	9
	36		57	228	114	35	·16	38	34	10	84	18	3	2¾	30197	13650	13	3	26
	24		48	165	104	30	10	28	24	7	63	12	2	2	22475	10920	9	2	27
	18		40	130	70	23	8	24	20	6	50	10	1¾	1¾	17836	9083	8	1	7
	16		36	126	64	21	7	22	19	6	48	9	1½	1½	17240	8575	6	0	12
Eaft India fhips	-	1200	40	135	70	22	5				30	6	3	2½		41623	9	3	25
		700	30	107	60	20	4				26	5	2½	2		31395	7	0	12
Weft India fhips	-	500	16	64	34	13	3				16	4	2	1¾		22919	4	3	17
		400	12	60	30	9	2				13	3	1½	1½		20815	3	0	25

Brig's Mainſail.—This ſail is quadrilateral, and made of canvas N° 5 or 6. The fore-leech is in depth from the under part of the hounds of the main-maſt to the boom, and the depth of the after-leech is about one-third more than the depth of the fore-leech. The head is bent to the gaff, and ſpreads within nine inches of the cleats on the outer end, the fore-leech to hoops encircling the maſt; and the foot is ſpread on the boom within eighteen inches of the ſheave-hole at the outer end.

Gores.—The head and maſt-leech are gored with a roach. The *regular* gore on the head is from four to five inches *per* cloth, and the roach or ſweep ſhould be cut after the ſail is ſewed together. The foot is gored with a circular ſweep, at the rate of five or ſeven inches *per* cloth, leaving four or five ſquare cloths at the clue; or at the rate of fourteen to eighteen inches *per* cloth for every cloth in the maſt-leech, which has five or ſix gored cloths in it.

Seams are three inches broad for eight feet up the ſail from the foot, and two inches broad for eight feet down from the head; the remainder is one inch broad, the ſeams decreaſing gradually from one breadth to the other.

For *tablings, head-holes,* and *holes* on maſt or fore-leech, conſult the firſt and ſecond proceſſes in ſail-making.

Reef-bands.—This ſail has three, ſix inches broad, parallel to the foot. The upper reef is nearly half way up the fore-leech, and the other at equal diſtances between that and the foot.

Reef-banks are generally ſewed on the reef-band at each ſeam, on both ſides of the ſail.

Linings.—The after-leech is lined with one breadth of cloth from the clue to one yard above the upper reef-band; at the upper part half a yard of the lining is cut down, and the inner part is doubled under, or cut off. The peek-piece is one yard in length, and the fore-leech is lined with half a breadth of cloth; or ſometimes pieces one yard in length are put on at the tack and nock, and ſmall triangular pieces at each hole.

In ſewing on the bolt-rope, four inches of ſlack-cloth ſhould be taken up with the rope in every yard on the maſt-leech.

Large iron thimbles are ſtuck in the cringles at the *clue, peek, nock,* and *tack;* alſo in the cringles made on the leeches at the ends of the reef-bands: a luff-cringle is made on the maſt-leech, equidiſtant from the lower reef-band and the foot, which alſo has a thimble.

To find the quantity of canvas, refer to Rule 4.

Cutter's mainſail only differs from the former in the following particulars, *viz.* the canvas is of N° 1 or 2.

The *head* is generally wider, and the peeks leſs, for the cuſtoms, revenue, ſmuggling-cutters, and merchant ſervice, than thoſe of the royal navy. The former are better adapted for velocity, the latter for handſome appearance.

Reef bands.—To have four in number, eight inches broad, and put on parallel to the foot; the upper reef is about three-ſevenths of the depth of the maſt-leech from the foot, and the others equally divided between that and the foot.

The *ſeams* are five inches broad for twelve feet up the ſail from the foot, and three inches broad for eight feet down from the head; the remainder to be one inch and a half broad.

Slack-cloth to be taken up in ſewing on the bolt-rope is four or five inches in every yard in the depth of the maſt-leech.

Smack's mainſail is ſimilar to the above, and made of canvas N° 1 or 2. The after-leech is about one-fifth deeper than the maſt-leech.

Gores about ten cloths on the maſt-leech. The head is gored at the rate of four or five inches *per* cloth; and the foot, with a curve, at the rate of twelve or fourteen inches *per* cloth, for every cloth in the maſt-leech, it having a ſhort gore to the clue on five or ſix cloths, at the rate of three or four inches *per* cloth.

Linings.—The maſt-leech is lined with a breadth of cloth from the tack to the nock; the after-leech the ſame as the brig, and the peek is lined with a cloth one yard and a half in length.

Reef-bands the ſame as the cutter; and ſometimes a

Balance-reef is put on acroſs the ſail, from the nock to the upper reef-cringle on the after-leech.

Bolt-rope on the maſt-leech ſhould be three inches; and on the head, foot, and after-leech, one inch and a half; and four inches of ſlack-cloth ſhould be taken up with the rope in every yard on the maſt-leech.

Sloop's mainſail is like the ſmack's, but the after-leech is only one-third deeper than the maſt-leech.

Cutter's Tryſail.—This ſail is occaſionally uſed, inſtead of the main-ſail, in ſtormy weather, and made of canvas N° 1 or 2. In the head of this ſail there are only two-fifths of the number of cloths that are in the head of the main-ſail: the maſt-leech is about three-fourths of the depth of the maſt-leech of the main-ſail, and the after-leech is one-ſixth deeper than the maſt-leech.

Gores.—Eight or ten cloths are gored on the maſt-leech. The foot is gored with a curve at the rate of five or ſeven inches *per* cloth from the tack, leaving two or three ſquare cloths at the clue.

Reef-bands.—This ſail has three reef-bands, ſix inches wide, parallel with the foot, the upper one is three-eighths the depth of the maſt-leech from the foot, and the others are at equal diſtances between the foot and the upper one.

Strengthening-bands.—Three are put on, of half a breadth of cloth, at equal diſtances between the upper reef-band and the head, which are ſeamed on and ſtuck along the middle.

Seams ſhould be five inches broad for twelve feet up from the foot, and three inches broad for eight feet down from the head; the remainder is one inch and a half broad, to decreaſe gradually from one breadth to the other.

Linings, tablings, reef-banks, &c. &c. as the main-ſail.

Veſſels having one maſt only, have ſails peculiar to that claſs, which we ſhall briefly notice. Such are the

Square Sail, or *Croſs-Jack.*—This ſail is quadrilateral, made of canvas N° 6 or 7, cut ſquare on the head and leeches: the head is bent to the croſs-jack yard, and extends within ſix inches of the cleats on the yard arms. The depth of the ſail is about four-fifths of the depth of the fore-leech of the main-ſail.

Gores.—The foot is gored one inch or more *per* cloth, increaſing from the middle to each clue; having two or three ſquare cloths left in the middle.

Seams, tablings, and *head-holes,* as other ſails of the ſame ſize.

Reef-bands.—It has two, four inches broad; the lower one is at one-ſixth of the depth of the ſail from the foot, and parallel thereto; and the upper reef is at the ſame diſtance from the head.

Reef-banks are ſewed on the reef-bands, as on the main-ſail.

Linings.—One yard of cloth is put on at each clue, half a yard at each earing, and half a yard againſt every cringle on the leeches. Theſe linings are all put on the aft-ſide.

Cringle.—One is made at each end of the upper reef-band; and three bowline-cringles are made on each leech; the upper

bowline-cringle is made on the middle of the leech, and the others are equally diftant from that and the clue.

Clues are fometimes marled on; and, for this purpofe, ten marline-holes are made each way from the clues.

Bolt-rope on the foot and leeches, fhould be one inch and a half or two inches in circumference; and on the head, one inch, or one inch and a half.

Slack-cloth, when fewing on the bolt-rope, one inch fhould be taken up in every cloth in the head and foot.

Topfail is fimilar to other topfails made of canvas N° 6 or 7. The depth in the middle is one-third of the depth of the crofs-jack.

Gores.—From one to two cloths are gored on the leeches, and the foot is hollowed from one-third to half of the depth of the fail in the middle (to clear the jib-ftay), or at the rate of ten to twelve inches *per* cloth from the middle to each clue, the middle cloth being left fquare.

Reef-band of four inches broad is put on at one-third of the depth of the middle cloth from the head.

Bowline, cringles, &c. &c. as the fquare fail.

Gaff-topfail.—This fail is quadrilateral, and made of canvas N° 8. The fore-leech is four-fifths of the depth of the maft-leech of the main-fail. This fail is bent to the topgallant-maft, with a fmall yard on the head above the main-fail, and is only ufed in light winds.

The foot has nearly the fame number of cloths as in the head of the main-fail, and nearly three-fourths of the number of cloths are gored on the maft-leech.

Gores at the foot are the fame as the gores on the head of the main-fail, that the foot may anfwer to the peek of the main-fail, the head-gores being the fame.

Bolt-rope on the maft-leech fhould be one inch and a half; and on the head and foot and after-leech, one inch.

Saveall-topfail.—This fail is quadrilateral, made of canvas N° 8, cut fquare on the head and foot. The head is extended by haliards faftened to the earing-cringles, under the hollow of the foot of the top-fail, its foot fpreading the crofs-jack yard between the clues of the topfail. It is feldom ufed but in light winds.

Gores.—Two or three cloths are left fquare on the head, and the reft are gored for the leeches.

Bolt-rope round the fail is one inch in circumference.

Ringtail-fail.—This fail is quadrilateral, made of canvas N° 7 or 8. It is occafionally hoifted abaft the after-leech of the main-fail, to which the fore-leech is made to anfwer. The head is bent to a fmall yard at the outer end of the gaff; and the foot on the boom, which is prolonged by a piece lafhed to the outer end. The number of cloths in the foot is three-eighths the number of cloths in the foot of the main-fail; and the head has three-eighths of the number of cloths in the foot.

Gores.—The head has a regular gore, the fame as the main-fail, and the foot is gored with a gore of one inch *per* cloth, increafing to the tack.

Bolt-rope on the head, foot, and after-leech, fhould be one inch in circumference; and on the fore-leech one inch and a half.

A fail of this kind, but more fquare, is fometimes fpread in light winds, on a fmall maft, erected at the taffarel of fome veffels; the foot being fpread out on a boom that projects horizontally from the ftern.

Fore-fail.—This fail is triangular, made of canvas N° 1 or 2; and bends with hanks to the ftay next before the maft. The depth of the leech is nearly the fame depth as the maft-leech of the main-fail, and there are as many cloths in the foot as will bring it clear of the maft.

Gores.—The depth of the hoift, or fore-part, divided by the number of gored cloths, gives the length of each gore. The foot has a fhort gore of one inch or more *per* cloth, increafing to the clue; leaving one or two fquare cloths at the tack.

Linings, &c.—The leech-cloth is left three-quarters of a yard longer than the depth of the leech for the head-lining, and the cloth at the tack is fo cut as to fall to the foot and form its own lining; it has one cloth at the clue, to run up above the reef-bands, the fame as the main-fail.

Seams fhould be three or four inches broad at the foot, decreafing to one inch at the hoift.

Reef-bands.—To have two four inches wide, are generally put on at one-eighth of the depth of the fail afunder, the lower one being at that diftance from the foot. Sometimes a bonnet is ufed inftead of the lower reef.

Reef-hanks are generally fewed on, inftead of ufing reef-points.

Bolt-rope on the ftay to be two and a half or three inches in circumference, and on the foot and leech one inch and a half or two inches.

Slack-cloth.—Three or four inches of flack-cloth fhould be taken up with the rope in every yard on the hoift.

Head-ftick.—The hoift-rope is put through the holes in the head-ftick, then ferved with fpun-yarn, and fpliced into the leech-rope. The middle of the head-ftick is then feized to the head of the fail, and a thimble is feized in the bight of the rope.

Thimbles are generally ftuck in the cringles at the tack and clue.

Jib.—This fail is triangular, made of canvas N° 2 to 6, and is fometimes bent with hanks to a ftay before the fore-fail, or hoifts with halliards without a ftay. The number of cloths in the foot is two-thirds the number in the foot of the main-fail, or wide enough to fpread the bowfprit, and the depth of the leech is about one yard for every cloth in the foot.

Gores.—The foot is gored with a fweep, at the rate of from four, five, to fix inches *per* cloth, increafing to the clue, leaving one fquare cloth at the tack; fometimes the fourth and fifth cloths from the tack are left fquare, and a fhort gore from thence to the tack of one inch *per* cloth.

Linings.—The leech-cloth is left three-quarters of a yard longer than the depth of the leech, for the head-lining and tabling; the cloth at the tack is cut fo as to fall to the foot and form its own lining; and the clue-piece is two yards in length.

Seams on the foot fhould be three or four inches broad, and fhould decreafe to one full inch on the hoift.

Bolt-rope, if hoifted on a ftay, the rope on the hoift fhould be two inches and a half or three inches in circumference; but if not hoifted on a ftay, the rope on the hoift fhould be five inches. The rope on the foot and leeches fhould be two inches and a half.

Slack-cloth.—Four or five inches of flack-cloth fhould be taken up in every yard in the hoift, when roping, and the rope on the hoift put through the holes in the head-ftick, and completed as the fore-fail.

Obferve, the *fecond jib* is feven-eighths the fize of the *firft jib*, and the *third jib* is three-fourths the fize of the *firft jib*; but they are both made like the *firft jib*, as above.

Storm Jib.—This fail is triangular, and made of canvas N° 1 or 2. It is two-thirds the fize of the firft jib, and is ufed in ftormy weather.

Gores.—The foot is gored at the rate of five or fix inches *per* cloth, increafing to the clue.

Seams.—To be three or four inches broad at the foot, and decreafed to one inch on the hoift.

Lining.—The clue is lined with a breadth of cloth one yard and a half in length; a piece one yard long is put on the peek, and the cloth at the tack is fo cut as to fall to the foot, and form its own lining.

Strengthening-bands, of half a breadth of cloth, are put on parallel to the foot, at one-third of the depth of the fail afunder.

Bolt-rope on the hoift fhould be five inches in circumference, and on the foot and leech two inches and a half.

Slack-cloth.—Four inches of flack-cloth fhould be taken up in every yard on the hoift when roping.

Flying Jib.—This fail is triangular, made of canvas N° 6, and is two-thirds the fize of the *firft* jib. It is the foremoft fail, and hoifts without a ftay.

Gores.—The foot is gored with a fweep, at the rate of eight or nine inches *per* cloth, increafing to the clue.

The *piece* at the *clue* is one yard and a half in length; that at the *peek* is one yard; and the cloth at the tack is fo cut as to fall to the foot.

Seams fhould be two inches and a half broad at the foot, and decreafe to one inch at the hoift.

Bolt-rope on the hoift fhould be three inches and a half in circumference; on the foot two inches, and on the leech one inch.

Slack-cloth.—Three inches of flack-cloth fhould be taken up with the rope in every yard in the hoift.

Thimbles are fometimes fpliced in the tack and peek.

Boat Sails.

Settee-fail.—This fail is quadrilateral, made of canvas N° 7 or 8. The head is bent to the latteen-yard, and extends within fix inches of the cleats at the arms.

Gores.—The cloth at the tack is cut goring to the nock, and the bunt is the depth of the reef, which is one-fifth of the depth of the leech. The depth of the leech is five-fixths of the length of the head. The length of the head, divided by the number of cloths in it, gives the length of each gore. The foot is cut with a curve, after the fail is fewed together.

Head-holes and *reef-hanks* as other fails, with fmall *cringles* made on the leech at the *reef*, *nock*, and *peek*.

Lug-fail.—This fail is quadrilateral, made of canvas N° 7 or 8. The head is bent to a yard, and extends within four inches of the arm-cleats. The fore-leech is as deep as the length of the head, and the after-leech is nearly one-half more in depth than the fore-leech.

Gores.—Two or three cloths are gored on the fore-leech, and an even gore of fix inches *per* cloth is made on the head. The foot is gored with a curve; the cloth at the clue being cut with a three-inch fhort gore; the next cloth is fquare, and the cloths from thence to the tack are gored at the rate of fix or eight inches *per* cloth.

Reefs.—Two in number parallel to the foot; the upper reef is half way up the fore-leech, and the other is equally diftant from that and the foot. Sometimes *reef-bands*, three or four inches broad, are put on at the reefs; but when thefe are not ufed, holes are made one in every feam, for *points* or hanks are fewed on inftead.

Holes.—Two fmall ones are made in each cloth in the head.

Cringles are made on the leeches at each reef; *earing-cringles* are made at the nock and peek; and ten or twelve ftrands in the length of the bolt-rope are feized at the tack and clue.

Latteen-fail.—This fail is triangular, made of canvas N° 7 or 8. The head is bent to the latteen-yard, extending within fix inches of the cleats at the arms.

Gores.—The length of the head, divided by the number of cloths, gives the length of the gore of each cloth. The foot is cut fquare.

Two fmall *holes* are made in each cloth along the head, through which it is laced on the yard.

Bolt-ropes for this and the two foregoing fails are alike; that is, one inch on the head, and one inch and a half on the foot and leeches.

Obferve, if this fail is bent to the maft the head becomes the fore-leech, and it is called a *fhoulder-of-mutton fail.* But if to the maft and a top-maft, which flides up and down, a *fliding-gunter fail.*

Spritfails.—Thefe fails are quadrilateral, made of canvas N° 7 or 8. The fore-leeches are laced to their refpective mafts; and their heads are elevated and extended by a fprit, or fmall yard, that croffes the fail diagonally from the lower part of the maft to the peek.

The *fore-leech* is nearly the depth of the maft, fo as to clear the gunwale a few inches.

Gores.—The main and fore fpritfails have one or two cloths gored at the fore-leech. The heads of them have a regular gore of twelve or fourteen inches *per* cloth, and the foot is cut fquare. The fore-leech and foot of a mizen-fpritfail are cut fquare, but the head has a regular gore of eleven inches *per* cloth.

Holes are made on the fore-leeches about one yard afunder for lacing them to the maft, and the mizen three-quarters of a yard. Holes are alfo made at each feam acrofs the fail of main and fore for a reef, at one-fifth the depth of the after-leech from the foot for the points or reef-hanks, inftead of being fewed to the fail.

Small bights are made at the tack, nock, peek, and clue.

Fore-fail and Jib.—Proportionally the fame as the laft mentioned.

SAIL-*Loft*, a room or fhed wherein fails are made.

SAIL-*Room*, in *Ship-Building*, an apartment or place of referve, built between decks, upon the lower deck or orlop, to contain the fpare fails.

SAILS alfo denote the vanes of wind-mills; or the arms or flights, by which the wind has its effect on them.

Thefe are either horizontal or perpendicular. See WIND-MILL.

Salt

SALT, Sal, in *Chemiſtry*, is a term ſo variouſly applied as not to admit of an accurate definition. It is obſerved, however, that the general and the moſt ancient idea of a ſalt is, a cryſtallizable ſubſtance, conſiderably ſoluble in water, and highly ſapid; but for the ſenſe in which the term is at preſent applied, or of acids with alkalies, earths, or metallic oxyds, ſee Salts. See alſo the references under Sal, and Rock-*Salt*.

Salt, in the *Manufactures* and *Domeſtic Economy*, generally ſignifies the common culinary ſalt, which in a ſtate of purity is called muriate of ſoda. See *Muriate of Soda*, under Soda.

Under this head we ſhall give an account of the different varieties of the common culinary ſalt, and deſcribe the different proceſſes by which it is manufactured.

Alimentary or common ſalt may alſo be diſtinguiſhed into various kinds, according to the various ways of preparing it. Hence we have,

1. *Bay*-ſalt, prepared by evaporation, by the heat of the ſun. This ſalt is of two kinds; the firſt drawn from ſea-water, as is practiſed in France, Spain, and Portugal, and many other hot countries; the other from the water of ſalt-ſprings, or lakes, as in the Cape Verd iſlands, in the iſland of Tortuga, Turk's iſland, and many parts of America. The firſt kind, in time of peace, is imported into Great Britain in large quantities. America and its fiſheries are commonly ſupplied with the latter.

The ſeveral kinds of bay-ſalt made in the different parts of the world are found to differ greatly from one another in ſeveral particulars; as, 1. In the ſize of the cryſtals, which is owing to the heat of the ſun, and the time it lies in the pits. The French cream of ſalt, and the blown ſalt of the iſle of May, are fine and ſmall-grained. The Portugal ſalt is larger grained than that of France; and that of Tortuga is larger than either. 2. In purity: as all bay-ſalt has ſome mud, ſlime, or the like, in the making, and ſome kinds are mixed with the bittern ſalt, or what is called Epſom ſalt. 3. They are all more white while dry, and more pellucid when moiſt; and they differ in colour, according to the earth which makes the bottoms of the pits. Thus, ſome of the French bay-ſalt is grey, ſome reddiſh, and ſome white, according as a blue clay has lined the pits, or a red or white one. 4. Some kinds of bay-ſalt are more apt to contract a moiſture from the air than others: an imperfection to which the common ſorts of marine ſalt are much more ſubject: this is ſometimes owing to the ſmallneſs of the grain, and ſometimes to a mixture of a calcareous or alkaline ſalt with it, or to a combination of earth with marine acid. And, 5. Some kinds have an agreeable ſmell in large heaps; ſuch are the Portugal, and the Hampſhire bay-ſalts; and this ſeems owing to the ſea-water they were made from having a bituminous matter in it. 6. It differs greatly in taſte, according to the various foreign mixtures it contains; and it will often alter in taſte, and other qualities, by long keeping. Thus the ſalt of Peccais is ſo bitter, when new made, as not to be eatable, but after keeping a while, it becomes very pleaſant. This is owing to its containing at firſt a large proportion of the bittern ſalt, or Epſom ſalt, which liquefies in keeping, and running off in form of a fluid, leaves the reſt of a good taſte. In general, bay-ſalt is much fitter for uſe after it has been kept ſome time in a dry place, than when it is firſt made.

2. *Marine* ſalt boiled, which is extracted from ſea-water by coction.

3. *Brine* ſalt, or fountain ſalt, prepared by boiling from natural brine, whether of ponds and fountains, or of lakes and rivers.

4. *White* ſalt, prepared from ſea-water, or any other kind of ſalt-water, firſt heightened into a ſtrong brine by the heat of the ſun, and operation of the air.

5. *White* ſalt, prepared from a ſtrong brine, or lixivium drawn from earth, ſtones, or ſands, ſtrongly impregnated with common ſalt.

6. Refined rock-ſalt, which is boiled from a ſolution of foſſile ſalt in ſalt-water, or in freſh. And,

7. *Salt upon ſalt*, which is made from bay-ſalt diſſolved in ſea-water, or other water, and boiled to a white ſalt.

All theſe kinds, except the firſt, are comprehended by Dr. Brownrigg under the general denomination of *white* ſalt.

There is no ſoluble ſalt found in nature ſo abundant as the ſalt under conſideration. We find it in ſome proportion in almoſt every animal and vegetable ſubſtance. In the earth it is found in vaſt maſſes, conſtituting rocks of ſuch extent, as to afford an exhauſtleſs ſource of this valuable ingredient of our food. The moſt remarkable of the ſalt-mines, which are excavations made into theſe rocks, are at Wilieſka in Poland, Catalonia in Spain, Altemonte in Calabria, Loowur in Hungary, Tunis in Algiers, and Cheſhire, in this country. Sources of a ſimilar kind have alſo been diſcovered in America. Theſe rocks are ſometimes almoſt pure ſalt, requiring merely to be reduced to powder. In others it abounds with earthy matter, and ſometimes with oxyd of iron, giving it various colours. The foſſile ſalt of Cheſhire is of the latter kind, and requires to be diſſolved in water, and evaporated, to obtain it in cryſtals. See Rock-*Salt*.

Salt-ſprings are another ſource of ſalt, and ſome lakes abound with a conſiderable quantity. The ſea itſelf is the principal of this claſs, which would furniſh a ſufficient ſupply for the uſe of man, if no other ſource of it exiſted. Indeed, the circumſtance of the ſea abounding with more of this ingredient than any other, is a ſufficient proof of what we have before aſſerted, that it is the moſt plentiful ſoluble ſubſtance in nature. The water of the ſea, which raiſed in the ſtate of pure water, and afterwards filtering through the earth

and mountains, brings to that immenfe refervoir every thing foluble which it finds in its way. Hence we find many other fubftances befides falt in fea-water. This will be exhibited in a tabular form hereafter. The falt-works of Wielicfka, in Poland, are upon an immenfe fcale. The fubterraneous excavations extend upwards of three miles. Dwellings and chapels are formed in the folid rock, having the appearance of enchantment. The number of people employed are from twelve hundred to two thoufand. They are faid not to live long, being liable to a complaint in the cheft. Great quantities of this falt require merely to be pulverized.

In Chefhire, particularly in the neighbourhood of Northwich, the falt-works are very extenfive. Great quantities are got in the folid form, but not fufficiently pure for ufe. In this ftate it is conveyed from the mines to the Chefhire fide of the river, nearly oppofite to Liverpool. It is at this place diffolved in the fea-water, from which it is afterwards feparated by evaporation and cryftallization, by a procefs which we fhall defcribe.

There are alfo in the fame diftrict falt-works, at which the falt called Chefhire falt is extracted from brine. Thefe works are defcribed very intelligibly by Dr. Holland, in the Report of Agriculture for the County of Chefhire. See Rock-*Salt*.

We fhall give a brief account of the procefs employed here for extracting the falt, for the facts of which we are indebted to the above author. The different ftates in which this falt is fold has given it different appellations, which are, *ftoved* or *lump falt*, *common falt*, and another variety in the form of large cryftals, called *fifhery falt*. In making the firft, the brine is put into pans of great furface and little depth, made of wrought iron, after the manner of fteam-engine boilers. The fire being made to play uniformly over the bottom, the brine, which is fully faturated, is raifed to the temperature of 226°. This high temperature, which is 14° above the boiling point of water, is induced by the prefence of the falt. As foon as the liquid is hot, a white powder, fometimes tinged with oxyd of iron, becomes feparated. This is partly fkimmed off, and fome falls to the bottom of the pan. This is moftly carbonates of lime and iron, which were diffolved in an excefs of carbonic acid, and which is driven off when the heat is applied. It may here be remarked, that the ftratum of red marle in which the falt veins are found, contain carbonate of lime; and it is fo liable to contain that excefs of carbonic acid by which it becomes foluble, that the fprings of thofe countries where the fame red marle abounds, are highly charged with carbonate of lime, which is precipitated by heat. The removal of the carbonates above-mentioned from the brine, as well from the furface as from the bottom, is called clearing the pan. Some brines abound with this impurity more than others, and fome contain none at all. The liquid now becomes clear, and cryftals of falt form on the furface till they fall, by their accumulating gravity, in the fpace of from eight to twelve hours. The principal part of the water is evaporated; the falt is now taken out with wooden fhovels, and put into conical bafkets, called *barrows*, from which the liquid part may drain. The falt is then dried in a ftove, where it lofes about one-feventh of its weight, and affumes the lumpy form, from which it takes its name.

After the pan has been ufed for a few weeks, the bottom becomes coated with the precipitates above-mentioned to a confiderable thicknefs. Thefe require to be removed by mechanical means, being almoft as compact as ftone. It would be an advantage to remove this fubftance oftener. It not only lofes time by protracting the procefs, but the bottom of the pan becomes heated fo hot as foon to be deftroyed by the action of the air.

The *common* falt is made by the fame procefs, but it is not ftoved after draining, and the evaporation is conducted more flowly, the temperature being from 160° to 170°.

The *fifhery* falt is made by the fame apparatus, and from the fame brine, but the evaporation is ftill flower than the laft, the temperature being only from 100° to 110°, and the procefs lafts from feven to ten days. By this means the cryftals become much larger and harder, and hence are better adapted for the ufe of fifheries. All thefe varieties of falt, and many others, have been analyfed by Dr. Henry of Manchefter; an account of which has been publifhed in the Philofophical Tranfactions for 1810. We fhall in the fequel to this article give a table of the principal facts, with other judicious remarks, given by this celebrated chemift.

The falt-fprings of Namptwich, in the fame county, and Droitwich in Worcefterfhire, are evaporated by a procefs fimilar to that above defcribed. The falt which they afford is held in high eftimation for its great whitenefs.

Before we quit the fubject of the Chefhire falt, it will be proper to point out the advantage derived from fending the rock-falt to the fea-coaft to be manufactured. The fea-water, in which it is there diffolved, being faturated with falt, 100 tons of this brine afford 23 tons of falt; the fame quantity of fea-water affording 2 tons 27 cwt. which would require the fame quantity of fuel to evaporate it. See Salt-*Brine Springs*.

Confiderable falt-works are carried on in Scotland, and in the northern counties of this country on the fea-coaft, by the evaporation of fea-water. At Lymington, in Hampfhire, the fea-water is evaporated to one-fixth of the whole by the action of the fun and air.

The works in which the fea-water is heightened into brine are called fun-works, or out-works. Thefe are conftructed on a flat down or oozy beach: within a mole, which is raifed, if neceffary, to keep out the fea, there is a large refervoir, or feeding pond, communicating with the fea by a fluice, and adjoining to this refervoir a long trench, parallel to which there are feveral fquare ponds, called brine-pots, nine or fometimes twelve placed in a row, and parallel to this two other rows of the fame kind; beyond the third row there is a row of larger ponds, three in number, called fun-pans, with each of which three or four of the brine-pits in the third row communicate by narrow openings; and thefe often communicate with a larger pond, called the common fun-pan, from which the brine flows into large covered cifterns (made very tight of brick and clay) adjoining to the boiling-houfe. The bottoms of the ponds are in feveral places formed of an oozy mud, well trodden and laid fmooth; and in the brine-pits and fun-pans covered with fea-fand. The bottoms of all the pits form an inclined plane, higheft at the refervoirs, and loweft at the common fun-pan. The partitions between the ponds are of mud and earth, about two feet broad, with little openings, by which the pits communicate with one another. The fea-water, received at full fea into the refervoir, is thence let out, as occafion requires, into the trench, and from the trench into the firft row of brine-pits; and when they are duly filled, the openings between them and the trench are clofed with mud. The water, after ftanding for fome time in thefe pits, is let out into the fecond row; and after a certain time, according to the degree of evaporation, into the third row of pits; thofe of the firft row being again filled; and thus they are filled and emptied alternately. When the brine is fufficiently evaporated in the third row of brine-pits, it is fuffered to flow

into the common ſun-pan, where its weight is examined by glaſs hydrometers; and being found of due ſtrength, it is drawn from thence into the ciſterns, where it remains till they are ready for boiling it. The ſea-water, thus carried through the whole work, is called a courſe of brine; and in hot weather, it acquires its proper ſtrength in twenty-four hours; but, if ſhowers approach, it is drawn into the ciſtern before it is brought to its full ſtrength. In this courſe the ſalt-water ſtands deepeſt in the pits of the firſt row, and is gradually ſhallower in the others, till it arrives at the ſun-pan, where it is ſhalloweſt, and in the common ſun-pan it is ſomewhat deeper, being about ſix or ſeven inches deep. After this manner, if the ſeaſon proves favourable, they make as much brine as keeps them boiling till near Chriſtmas; after which they repair their pans and furnaces; and prepare their Epſom ſalt from the bittern, and begin again to make brine about April.

The next operation is performed by artificial evaporation, in boilers ſimilar to thoſe uſed in other ſalt-works. The pans in which they boil the ſalt at Lymington are of lead, of a ſquare form, and ſmaller than thoſe uſed for boiling ſea-water into ſalt. They have uſually four of theſe in a ſaltern, placed in a row, with a furnace to each of them. The chimnies are carried up by the ſide of the wall, which divides the boiling-houſe from the fire-houſe; and the ſmoke is conveyed from each furnace into theſe chimnies by two flues, one on each ſide of the mouth of the furnace. To each of theſe flues is fitted a regiſter, or plate of iron, placed horizontally, which may be drawn out, or thruſt in over the flue ſo as to cloſe it, and prevent the ſmoke from aſcending through it; and by means of theſe regiſters and vent-holes, and doors to the mouths of the furnaces and aſh-pits, they are able to regulate the fires in the exacteſt manner, and damp them while the ſalt is graining, or ſmother them quite out, if they find occaſion. In the boiling-houſe they have a chimney to convey off the vapours from each pan; which is a ſquare funnel of boards. There is only one long walk in the boiling-houſe, on the ſide of the pans oppoſite to the mouths of the furnaces, and between this walk and the wall are placed large wooden troughs, with ſeveral little holes at their bottoms; into which troughs the ſalt, when drawn out of the pans, is put to be drained from the bittern.

The proceſs varies, in ſome degree, from that uſed in Cheſhire. The ſalt is not removed from the boiler till the whole of the water is evaporated. It is then taken out all at once, and placed in troughs with holes in the bottom. A certain quantity of moiſt uncryſtallizable matter adheres to this ſalt, which drains through the above-mentioned holes into pits below. Immediately under the holes are placed upright ſtakes or pillars, down which the liquid runs, and upon which a portion of ſalt cryſtallizes in maſſes, which in ten or twelve days weigh as much as 60 or 80 lbs. Theſe maſſes are called *ſalt-cats*, and amount to $\frac{1}{400}$th of the whole ſalt manufactured here. The liquid which paſſes into the pit is of a very ſharp bitter taſte, and is called *bittern*. It is reſerved for the winter ſeaſon, when the ſalt-works are ſuſpended, and then undergoes evaporation to a certain extent. A little more common ſalt is ſeparated, which is reſerved to add to the ſalt-brine. The evaporated fluid is placed in wooden coolers, eight feet long, five feet broad, and one foot deep, where it affords cryſtals of Epſom ſalt (ſulphate of magneſia). The remaining liquid is drained off from the cryſtals, and runs away. This is called ſingle Epſom ſalt, to diſtinguiſh it from the ſame article, after a ſecond ſolution and cryſtallization, which is termed double Epſom ſalt. Four or five tons of Epſom ſalt are produced from a quantity of ſea-water which has yielded two of common ſalt and one of cat-ſalt. We are indebted to Dr. Henry's eſſay above alluded to for the account of theſe ſalt-works, who had it from a gentleman reſiding at that place.

The artificial method of promoting the evaporation of ſea-water, and the preſerving the brine in the Engliſh ſalt-pits from being diluted with rain, propoſed by Dr. Brownrigg, is as follows. A number of ſalt-pits ſhould be made in a row in the marſh, from eaſt to weſt, and their bottoms lined with plaiſter, or ſome ſtrong cement that will not eaſily break up; and by this caution, the ſalt may be drawn white and pure like the Portugal kind, not grey like the French. Over each pit covers ſhould be made of thin boards, or rather of canvas painted white, and ſtretched on frames of wood, and theſe ſhould be fixed to ſtrong poſts, erected on the north ſide of the pits, and contrived to be eaſily drawn back to them, in the manner of drawbridges. Theſe covers, thus fixed, may be let down over the pits in the manner of a ſhed or pent-houſe, in rainy weather, to keep the brine from being diluted with freſh water; and in dry weather they may be raiſed almoſt to a perpendicular, but inclining a little towards the ſouth, ſo as to form a wall with the ſouth aſpect; and thus they would ſerve for a double uſe, being a covering to the pits in rainy weather, and reflectors of the ſun's heat in dry weather. The reflection of ſo large a body of the ſun's rays, in the courſe of a bright day, would greatly promote the evaporation of the brine; and the hinges on which the reflectors turn, being placed at ten inches from the ground, when the reflectors ſtand upright, there will be a ſpace under them, through which the air will continually flow in a briſk current, and this will greatly promote the evaporation of the water.

The paſſages of communication between the pits muſt be narrow and winding, and muſt be wholly ſtopped up in wet weather, that no freſh water run into the brine. This channel ſhould be covered alſo with boards, and, at the entrance of the pits, there muſt not be a pond, as is the cuſtom in France, but only a narrow covered trench, running parallel with the ſide of the pits, which is oppoſite to the reflectors; and the pond, which forms the entrance of the pits in the French ſalt-marſhes, muſt in theſe be detached from them, and inſtead of it, there muſt be formed a fourth brine-pond, communicating with the third by a long and narrow channel.

If theſe contrivances ſhould be reduced to practice in England, the ſalt will probably cryſtallize much faſter there than in the French marſhes, and the brine may be kept as deep, and even deeper than in the French pits; and a ſhower of rain will only retard the work for the ſmall time in which it is falling: whereas, in the French works, it throws them back three or four days, as no ſalt can be formed till all the water it brought be evaporated.

Four ciſterns may be dug adjoining to the brine-pits, to admit the brine in the ſalt-ponds, when the weather is very rainy; and as to the ſalt-water in the reſervoir, if it ſhould be found neceſſary to preſerve it from rain in ciſterns, when ſo much rain falls as to make it freſher than ſea-water, it may be let out, and ſea-water admitted in its place. And, in order to promote the evaporation, and to make the ſalt-water in the reſervoir fitter to ſupply the firſt brine-pond with brine of a due ſtrength, it may be proper, by means of a ſmall fire-engine, continually to force up the ſalt-water in the reſervoir, as often as occaſion requires, and, by means of a diverger, fitted to the engine, to make it deſcend again into the reſervoir like a ſhower of rain: by which means, the evaporation of the watery vapours will be greatly pro-

moted after much the ſame manner as is practiſed at ſeveral of the ſalt-works in Germany, where the brine is very weak.

Thus by augmenting the force of the ſun's heat, and of the air, by promoting the evaporation of the watery vapours, and preventing the brine from being diluted with rain, it is very probable that, during the ſummer ſeaſon, double the quantity of ſalt might be prepared at an Engliſh work with theſe contrivances, that is now uſually prepared at a French ſalt-marſh of equal magnitude.

Beſides theſe methods of managing ſea-water, it is certain that very large quantities of bay-ſalt might be prepared in England with great eaſe, from the natural brine of ſalt-ſprings, and from the common foſſile or rock-ſalt of Cheſhire, diſſolved in weak brine, or in ſea-water. Upon the whole, the bay-ſalt might thus be made here at a moderate price, and in ſufficient quantities to ſupply both the nation itſelf, and all our colonies.

Dr. Watſon, in his Chemical Eſſays, vol. ii. p. 58, having found, by experiment, that, in a ſummer-day of ſixteen hours, three gallons of water may be diſperſed into the air, by a warm ſun and a briſk wind, from the ſurface of a linen cloth, equal to one ſquare yard, ſuggeſts a method of manufacturing bay-ſalt, by wetting and drying alternately any number of ſquare yards of coarſe cloth: and he obſerves, that one labourer, aſſiſted by proper mechanical contrivances, might be equal to the daily management of a thouſand yards, or more. By this plan in favourable weather there would be daily evaporated twenty-four thouſand pounds of water, which, ſuppoſing ſea-water to contain one thirty-ſecond part of its weight of ſalt, would give ſeven hundred and fifty pounds of ſalt.

He adds, that thoſe who have ſeen the artifice of ſtrengthening brine, which is practiſed in Franche Comté, and other places, by making it drip through faggots, in order to increaſe the evaporation, by increaſing the ſurface of the water, which is expoſed to the air, will not be ſurprized at this method of evaporating water.

Marine ſalt is prepared by boiling ſea-water. This ſalt is only made in countries where great quantity of fuel can be had at a very low price, or where the ſun has not force enough; and is therefore made in few counties of England, except on thoſe parts of the Britiſh coaſt which moſt abound in pit-coal. This has thence got the name of *Newcaſtle ſalt.*

The ſalt-works in the north are the moſt extenſive, and are wholly carried on by artificial heat.

The moſt convenient works for the manufacture of this ſalt are conſtructed in the following manner. The ſaltern is erected at ſome convenient place near the ſhore; it is a long and low building, conſiſting of two parts, one called the fore-houſe, and the other the pan-houſe, or boiling-houſe. The fore-houſe ſerves to receive the fuel, and cover the workmen; and in the boiling-houſe are placed the furnace, and the pan or boiler in which the ſalt is made. And in ſome places they have two pans, one at each end of the building, and the fuel and place for the workmen are in the middle. The furnace opens into the fore-houſe by two mouths, and from theſe is carried up a wall to prevent the aſhes from flying to the ſalt-pans, and in this is a door of communication between the two houſes. The body of the furnace conſiſts of two chambers, divided from one another by a brick-work, called the *mid-feather*, which from a broad baſe terminates in a high edge nigh the top of the furnace, and by means of ſhort pillars of caſt-iron fixed upon it, ſupports the ſalt-pan. The pans are oblong and ſhallow, the common meaſure being fifteen feet in length, twelve feet in breadth, and ſixteen inches in depth; they are commonly made of plates of wrought iron, joined together with nails, and the joints filled with a ſtrong cement; and the bottom of the pan is prevented from bending down, or changing its figure, by hooks faſtened to ſtrong iron-bars which are placed acroſs it. Sometimes the ſides, which are not always covered with liquid but expoſed to the air, are made of lead, iron being liable to be corroded.

Between the ſides of the pan and the walls of the boiling-houſe there runs a walk, five or ſix feet broad, where the workmen ſtand to draw out the ſalt. The roofs are wood, and are faſtened with pegs of wood, nails mouldering away into ruſt in a few months.

Not far diſtant from the ſaltern on the ſea-ſhore, between full ſea and low-water mark, they make a little pond in the rocks, or with ſtones in the ſand; this they call a *lump;* and from this pond they lay a pipe, through which, when the ſea is in, the water runs into a well adjoining to the ſaltern, and by this well they pump it into troughs, by which it is conveyed into their ſhip or ciſtern, in which it is ſtored up till they have occaſion to uſe it.

The ciſtern is built cloſe to the ſaltern, and may be placed moſt conveniently between the boiling-houſes on the back ſide of the fore-houſe. It is made either of wood, brick, or clay, and ſhould be covered with a ſhed, that the ſalt-water in it may not be weakened by rains, and ſhould be placed ſo high that the water may conveniently run out of it into the pans. When the ſea-water has ſtood in the ciſtern till the mud and ſand are ſettled from it, it is drawn off into the ſalt-pan; and at the four corners of the ſalt-pan, where it is ſupported by the brick-work, and conſequently the flame does not touch its bottom, there are placed four ſmaller leaden pans and ſcratch-pans, which, for a ſalt-pan of fifteen feet, are uſually about a foot and a half long and a foot broad, and three inches deep. Theſe have a bow or circular handle of iron, by which they may be drawn out with a hook when the liquor in the pan is boiling.

The ſalt-pan being filled with ſea-water, a ſtrong fire of pit-coal is lighted in the furnace, and then, for a pan which contains about fourteen hundred gallons, the ſalt-boiler takes the whites of three or four eggs, and incorporates them all with two or three gallons of ſea-water, which he pours into the ſalt-pan, while the water contained in it is only luke-warm, and mixes this with the reſt by ſtirring it about with a rake. In many places they uſe, inſtead of eggs, the blood of ſheep or oxen to clarify the ſea-water, and in Scotland they do not give themſelves the trouble of clarifying it at all. As the water heats, and approaches boiling, there ariſes a black frothy ſcum upon it, which is collected into four ſmall pans at each corner of the boiler, called "ſcratch-pans;" and a great part is alſo taken off with flat wooden ſkimmers. This impurity is earthy matter proceeding from the decompoſition of certain earthy ſalts, and is called by the workmen "ſcratch." After this the water appears perfectly clear, and by boiling it briſkly about four hours, a pan loaded in the common way, that is about fifteen inches deep, will begin to form cryſtals upon its ſurface. The pan is then filled up a ſecond time with freſh ſea-water, applying the eggs or bullock's blood, and the operation of ſkimming as before: about the time when it is half filled, the ſcratch-pans are taken out and emptied of a white powder, ſeeming a kind of calcareous earth, which ſeparates itſelf from the ſea-water during its boiling, before the ſalt begins to ſhoot. When theſe have been emptied they are again put into their places, where they are afterwards filled again. This powder, being violently agitated by the boiling liquor, does not ſubſide till it comes to the corners of the pan, where the motion of the maſs is ſmaller, and it there falls into theſe

pans placed on purpose to receive it. The second filling of the pan is boiled down after clarifying in the same manner as the first, and so a third, and a fourth; but in the evaporation of the fourth, when the crystals begin to form themselves, they slacken the fire, and only keep the liquor simmering; in this heat they keep it all the while that the salt is granulating, which is ten or twelve hours. The granules or crystals all fall to the bottom of the pan; and when the water is almost all evaporated, and the salt lies nearly dry at the bottom, they rake it all, altogether, into a long heap on one side of the pan, or into two heaps, one at each end of the pan, where it lies a-while to drain from the brine, and then is put into barrows and carried to the store-house, and delivered into the custody of his majesty's officers. In this manner the whole process is usually performed in twenty-four hours, the salt being commonly drawn out every morning. This is the method in most of our salt-works, but in some they fill the pan seven times before they boil up the salt, and so take it out but once in two days, or five times in a fortnight. In the common way of four boilings, a pan of the usual size, containing one thousand three hundred gallons, they draw from fifteen to twenty bushels of salt every day, each bushel weighing fifty-six pounds.

When the salt is carried into the store-house, it is put into *drabs*, which are partitions, like stalls for horses, lined at three sides, and the bottom with boards, and having a sliding-board on the fore-side to draw up on occasion. The bottoms are made shelving, being highest at the back, and gradually inclining forward; by this means the brine remaining among the salt, easily separates and runs from it, and the salt in three or four days becomes sufficiently dry. In some places they use cribs and barrows, which are long and conic wicker baskets for this purpose, and in some places wooden troughs with holes in the bottom. The saline liquor which remains from the making of salt, is what is called *bittern*.

The sides of the pans in which the salt is made, are soon crusted over with the same sort of matter, formed into cakes or crusts, that falls in powder into the scratch-pans; this the workmen call "stone scratch;" thus distinguishing it from that skimmed from the top, which they call "powder scratch:" they are obliged to cleanse the pans of it once in a week or ten days, otherwise they will be burnt. In England they do this with iron picks, but at Halle in Saxony they have a much better method; for they there take out the pans, and turning them bottom upwards, burn straw under them, by which means the matter of the crust loosens itself, and after this it falls off on being struck with a mallet or hammer.

In Lancashire, and some other parts of England, sea-salt is made in this manner; they pare off, in dry weather, in summer, the surface of the flats, which are covered at full sea, and bare when the tide is out. When they have procured heaps of this they put it into troughs, and pour fresh water on it; this washes off the salt that hung about the sand, and is received so impregnated into vessels set underneath the troughs So long as this liquor is strong enough to bear an egg, they put on more water; when an egg sinks in it they throw the sand out of the troughs, and put in fresh from the heaps. The water thus impregnated with salt they boil in leaden pans, and evaporate to a dryness, the salt remaining behind.

Brine or *fountain* salt is prepared from the water of salt wells and springs. See SALT-*Brine Springs*.

The ancient methods of boiling brine into salt, in Cheshire and Worcestershire, are accurately described in the Transactions of the Royal Society; and the method, formerly used in Staffordshire, is delivered in Dr. Plott's history of that county; but the method now generally used in England is this.

The brine being received from the well into a large cistern, is thence received, as occasion requires, into the salt-pan. These pans are of the same form with those used in the boiling of sea-salt, and usually hold about eight hundred gallons; in some places these are made of iron, and in others of lead. When the brine is put into the pan, a little blood is mixed with it, in order to clarify it, and leaden pans are placed at the corners to receive the scratch, or calcareous earth, that separates from them in the boiling. An ounce of blood is sufficient for eight hundred gallons of brine. In some places they clarify their brine with whites of eggs. As soon as it is boiled, it is carefully skimmed, and afterwards it is suffered to boil very briskly for some time, till the salt is granulated; after this the scratch is separated, and the fire slackened, till the whole salt is formed.

When they have separated the scratch, and the salt is ready to crystallize, they put into the pan several sorts of seasoning, as they call them, such as ale, butter, and the like, which they suppose correct the bad qualities of the brine, and make the salt of a smaller grain. After this they boil it very gently, and when as much salt is formed as will fill two or three of their wicker baskets, they rake it up to the sides of the pan, and fill it into the baskets, placing them over the leach trough, that the brine may drain into it from the salt. The salt taken out they call a "draught" of salt, and the operation, a "clearing" of the pan.

In this manner they draw the salt, and clear the pan five or six times during each process, leaving at last only a few quarts of brine at the bottom of the pan. The baskets into which they put the salt out of the pan are called also *barrows*; they usually contain about a bushel of salt, and are of a conic figure, open at the base. The whole process of working a pan of brine usually lasts about twenty-four hours. After the salt has drained an hour or two in the baskets, it is removed into the hot-house over the furnace, where it remains four or five hours to be thoroughly dried, and is then taken out of the baskets, and laid up for sale. In all the English salt-works, the leach brine, which is what remains in the pan after the salt is crystallized, and what drains from the salt in the baskets, is not thrown away, as it is in Germany, but is added to the pan next to be boiled. And beside the salt made in this manner, they have, at most of the English salt-works, a different kind, which they call *shivery salt*. This is of a larger and firmer grain than that prepared in the common way, and is stronger, being formed by a milder heat, and therefore more fit for preserving meat. When they would make this salt, they fill the pans on Saturday night, and then, as they draw out no salt on Sundays, there is a very moderate fire kept up all that day, and on Monday morning all the salt is taken out at one draught, having had time to form itself into larger crystals than ordinary, as it is eight and forty hours instead of four and twenty in forming.

They have also another kind of salt, made up in form of sugar-loaves, in small wicker baskets, which is thence called *loaf-salt*, or *basket-salt*. This is the whitest, driest, and finest grained of any salt, and is therefore greatly esteemed at table. In preparing this salt they use some resin and other additions, to break the grain and render it very small; others also, to this purpose, boil it the more briskly, and stir it briskly all the while. But in Cheshire, where the best basket-salt is made, they use no particular process about it, but only take the second and third draughts of every pan, which always are the purest salt; and they do not suffer

these to lie so long in the pan, as when they make salt of a larger grain, but take it out before it can form large crystals; by this means they have it of a fine small grain, and they then press it hard down into the wicker baskets, and when dried in the stove, they let it remain in the baskets for sale.

Not long since, Mr. Lowndes published a method of greatly improving the English brine-salt, so as to make it at least equal to the French bay-salt.

The method is this. Let a brine-pan, containing about eight hundred gallons of liquor, be filled with brine to within an inch to the top; then make and light the fire, and, when the brine is just luke-warm, put in either an ounce of blood from the butchers, or the whites of two eggs. Let the pan boil with all possible violence, and as the scum rises take it off. When the fresh or watery part is pretty well decreased, throw into the pan the third part of a pint of new ale, or the same quantity of the grounds of any malt liquor. When the brine begins to grain, add to it the quantity of a small nut of fresh butter, and when the liquor has stood half an hour longer, draw out the salt. By this time the fire will be greatly abated, and so will the heat of the liquor; let no more fuel be thrown on the fire, but let the brine gently cool, till a person can just bear to put his hand into it; keep it in that degree of heat as nearly as possible, and when it has worked for some time, and is beginning to grain, throw in the quantity of a small nutmeg of fresh butter, and about two minutes after that scatter throughout the pan, as equally as may be, an ounce and three quarters of common alum, pulverized very fine; then instantly, with the common iron scrape-pan, stir the brine very briskly in every part of the pan for about a minute; then let the pan settle, and constantly feed the fire, so that the brine may never be quite scalding hot, yet always a great deal more than luke-warm; let the pan stand working thus for about three days and nights, and then draw it, or take out the salt. The brine remaining will, by this time, be so cold, that it will not work at all, therefore fresh coals must be thrown upon the fire, and the brine must boil for about half an hour, but not near so violently as before the first drawing; then, with the usual instrument, take out such salt as is beginning to fall, and put it apart; then let the pan settle and cool. When the brine becomes no hotter than one can just put one's hand into it, proceed as before, and let the quantity of alum not exceed an ounce and a quarter, and about eight and forty hours after draw the pan, and take out all the salt. Lowndes's Brine Salt improved.

This is Mr. Lowndes's process; except that he afterwards directs cinders to be chiefly used in preparing the fires, the better to preserve an equal heat, and by that means also he proposes saving a considerable expence, asserting that at present cinders are so little valued in Cheshire, as to be thrown out into the highways. Mr. Lowndes adds, that in a pan of the size before-mentioned, there may be prepared, at each process, sixteen hundred pounds weight of salt from the best brine in Cheshire, and one thousand and sixty-six pounds from the ordinary brine of that country. This, as the process continues five days, is a little more than five bushels and a half of salt a day from the best brine, and a little more than four bushels a day from the ordinary kind.

The salt-boilers, and particularly those that prepare brine-salt, have long been accustomed to make use of various substances, which they call additions or seasonings, and mix them with the brine while it is boiling; either when they first observe the salt begin to form, or else afterwards during the time of granulation. The intention of these additions is to make the salt grain better, or more quickly form into crystals, to make it of a small fine grain, to make it of a large firm and hard grain, and less apt to imbibe the moisture of the air, to render it more pure, and to make it stronger and fitter for preserving provisions.

The additions commonly used for these purposes are wheat-flour and resin, in order to give the salt a small grain; butter and tallow, to make the brine crystallize more readily; new ale, stale beer, bottoms or lees of ale and beer, wine lees, and alum. Wine lees, new ale, stale ale, and the lees of ale and beer, are now generally rejected by the marine salt-boilers; except in the west of England, where the briners, who use them, affirm that they raise a large grain, and make their salt more hard and firm, and some say that they make it crystallize more readily.

Hoffman prefers the strongest ale; and Plot assures us that it makes the salt of a larger or smaller grain according to the degree of its staleness. Dr. Brownrigg apprehends that the only good effects which fermented liquors can have, as an addition, are owing to their acid spirit, which may correct the alkaline salts of the brine, and thus render the common salt more dry and hard, and less apt to dissolve in moist air. For correcting the alkaline quality of the brine, if any additions are thought necessary, he recommends stale ale or Rhenish wine; or perhaps malt vinegar would answer the same purpose. Alum and butter were long used in Cheshire, but the use of the former has been discontinued. Mr. Lowndes introduced it, with a view of correcting the flakyness and softness of brine-salt; but Dr. Brownrigg is of opinion, that alum cannot answer these purposes, and that it is not necessary; for, he says, that the grains of common salt will always be sufficiently hard, and of their natural figure, large size, and undeliquiable, if formed by a gentle heat and perfectly free from heterogeneous mixtures; and he imagines, that the goodness of Mr. Lowndes's salt is not owing to the alum, but to the gentle heat used in the preparation of it. The addition recommended by the Dutch will appear in the sequel of this article.

We may observe that bay-salt and boiled salt have respective different qualities, according as they are prepared at different places; and there are two general causes of this diversity; one respects the manner of preparing the salt, the other respects the quality of the water from which the salt is prepared. When sea-water or brine is boiled into salt, a portion of the acid, which is one of its constituent parts, is dispersed; and a greater or less portion is dispersed, according as the salt has been formed with a greater or less degree of heat. We have an instance of this, both in bay-salt compared with boiled salt, and in the different sorts of the latter, when compared with each other.

Bay-salt, which is prepared from sea-water, by the mild heat of the sun, is generally esteemed much stronger than the white salt, which is prepared likewise from sea-water, by boiling the water. Hence this salt is not only weaker, but more disposed to deliquiate in the air; both which imperfections are said to be corrected by a small addition of fresh acid, when the salt begins to concrete. Hence also distilled sea-water is manifestly impregnated with acid, so as to be unfit for drinking, or for the common purposes of life; unless a little chalk, vegetable ashes, or other like substances, be added in the distillation, to absorb and keep down the acid extricated by heat; by which means the distilled fluid proves perfectly sweet.

White salt is prepared by boiling either the natural brine of sea-water, or salt-ponds and springs, whence are obtained the marine salt and brine salt, or the stronger brine produced by artificial means, *viz.* by previous evaporation, or solution of fossile salt, or the impregnation of common salt drawn

from earths, ſands, or ſtones. Of this ſalt two very different kinds are required; the one for the uſe of the table, and the other as a condiment for proviſions. Its whiteneſs, dryneſs, and the ſmallneſs of its grains, are the properties which chiefly recommend the firſt kind, and its ſtrength and purity the latter.

Dr. Brownrigg has propoſed a method of improving the preparation of both kinds, founded on the following principles; *viz.* 1. That in the common proceſſes for making white ſalt, the ſalt is deprived of a conſiderable part of its acid ſpirit, by the violent boiling uſed in its preparation; whence it is rendered leſs fit for preſerving fiſh, fleſh, and other proviſions, than it would be if prepared with a more gentle heat. 2. That moſt kinds of white ſalt are rendered impure by the mixture of various heterogeneous ſubſtances, which render it leſs proper for preſerving proviſions than it would be if ſeparated from them.

In order to obtain a ſalt of this kind, free from all impurities, and in no reſpect weakened by a diſſipation of its acid ſpirit, let the ſea-water (if that be uſed) be heightened into a ſtrong brine by the ſun, after the method practiſed in Hampſhire, and other parts of England, or in a ſalt-marſh conſtructed after the French manner.

For this purpoſe, a ſaltern muſt be erected adjoining to the ſalt-marſh, and a large boiler, or ſalt-pan, made of iron, placed in it. The bottom of the pan may be of a ſquare figure, forty feet on each ſide, and its depth may be eighteen inches; or it may be made of a cylindrical form, forty feet in diameter, and eighteen inches deep, like thoſe uſed in Holland. The furnace over which the pan is erected may have four mouths, made on the oppoſite ſides at equal diſtances, for the convenience of receiving fuel. The fire may be made on a hearth; and within the furnace muſt be erected proper pillars of brick, or mid-feathers; and, if neceſſary, ſtrong poſts and croſs bars of iron, to ſupport the bottom of the ſalt-pan. There muſt be alſo four funnels, for conveying away the ſmoke, at equal diſtances, between the mouths of the furnace. If the pan be ſquare, the funnels may be carried up at its four corners, and the mouths may be under the middle of its four ſides. To the mouths muſt be fitted cloſe doors, and the funnels muſt be furniſhed with regiſters, for regulating the fire. When this apparatus is provided, let the ſalt-pan be filled with ſtrong brine, drawn from the ciſtern, and well cleared from its muddy ſediment. Then kindle a fire, and mix a ſufficient quantity of whites of eggs with the brine, in order to clarify it; let the brine boil gently at firſt, and let it be well ſkimmed. When this is done, diminiſh the fire, and apply a moderate heat, ſufficient to keep the brine of a ſcalding heat.

When the ſalt begins to grain, rake out the ſcratch, which will be found at the bottom of the pan. When the brine is thus fully depurated, in order to correct its alkaline quality, a proper quantity of four whey may be added to it; the brine being kept of a ſcalding heat, while the ſalt is graining or forming into cryſtals; and when moſt of it is cryſtallized, and lies in the pan almoſt dry on its ſurface, the fire muſt be damped by ſhutting the doors of the furnace and regiſters; and the ſalt muſt be drawn from the liquor to the ſides of the pan, and put into drabs, or proper veſſels, till the bitter liquor is drained from it, and then it will be fit to be uſed in the ſecond proceſs of refining.

In this way may be prepared a ſea-ſalt ſtronger, and of a much firmer and larger grain, than any kind of common white ſalt made by the ordinary methods; and alſo a ſalt for the table, better in quality and cheaper than that prepared by the common methods. However, it is neceſſary to obſerve, that the ſalt which is required of a fair grain, ſhould be granulated with quicker fires, and drawn out of the pan before it hath lain long enough to form itſelf into large cryſtals, ſo that it may be taken out at five or ſix draughts during the proceſs. The ſecond or third draughts will be the beſt ſalt, being moſt free from ſcratch, and the ſalts of the bittern. After the ſame manner, a good kind of white ſalt may be extracted from natural brine, and likewiſe from a ſolution of rock-ſalt in weak brine or ſea-water.

In the ſecond proceſs of refining, a ſufficient quantity of the white ſalt, prepared as above directed, ſhould be put into a large ciſtern, made of wood, or bricks and clay; and to this ſhould be added as much pure river-water as will be ſufficient to reduce it to ſtrong brine, almoſt fully ſaturated with ſalt; when the ſalt is diſſolved, and the brine has remained unmoved, a ſcum will ariſe which muſt be taken off, and a ſediment will fall to the bottom. Let the clear brine be drawn out of the ciſtern into a ſalt-pan, ſuch as has already been deſcribed in the firſt proceſs, well cleanſed from bittern; let a fire be kindled in the furnace, and the heat be ſo gentle, that the watery part of the brine may be ſlowly evaporated without any of the ſaline ſpirit; for this purpoſe the heat ſhould be regular, and leſs than the heat of boiling water; but the degree which ſalt can endure without any diſſipation of its acid ſpirit, is beſt known by experience, and may be adjuſted by the regiſters, &c. When the evaporation is ſo far advanced, that little ſaline cryſtals begin to appear on the ſurface of the brine, then may be added to it a ſufficient quantity of the acid muriatic ſpirit (in the proportion of about one, two, or three drops of the ſpirit to a gallon of the brine), ſo that neither the acid, nor the alkaline principle of the ſalt, may be predominant. When this is done, the evaporation muſt be continued until the ſurface of the ſalt in the pan is almoſt dry. The doors of the furnace and regiſters muſt then be cloſed, and the fire ſmothered out, and the ſalt, which will be found in large clear cryſtals, muſt be raked to the ſides of the pan, and having drained there a little while, be taken out, and put in proper veſſels to drain farther from the ſuperfluous brine, and it will be then fit for ſale.

The ſtrong brine which remains in the pan after the refined ſalt is drawn out, and the brine that drains from it, ought not to be mixed with the ſolution intended to be made into refined ſalt, but will ſerve to mix with the brine, to be boiled up in the firſt proceſs into common white ſalt. See on the ſubject of this article Brownrigg's Art of making Common Salt, 8vo. 1748, paſſim.

Foreign ſalt, which has undeſervedly been held in great eſtimation in this country, is formed from ſea-water, in hot countries where the natural heat is ſufficient to evaporate the water from the ſalt. The ſea is let into pits or baſins made on purpoſe, and lined with clay, to prevent the water from ſinking into the earth. When one quantity is evaporated more water is let in, till the brine becomes ſaturated.

The white ſalt of Normandy is not made by refining the bay-ſalt, but has this colour naturally when taken out of the pits. To make it they gather a muddy ſand on the flats of the ſhore, which the riſing tide has covered and impregnated with its waters for ſeven or eight days. This ſand being removed into pits for the purpoſe, diſcharges itſelf by degrees of all its water, which filtrates through ſome ſtraw, with which the opening of the pit is filled, and trickles into veſſels ſet on purpoſe to receive it. Of this water it is that they make their ſalt.

Their furnaces are of earth, and their boilers of lead: each furnace boils four leads. When the water with which they have filled the leads begins to boil, they take off the

fcum, which arifes in abundance; and in proportion as it diminifhes, throw in frefh water, which they continue to fkim, as before. When it thickens, they keep it continually ftirring, with a crooked ftick or ladle; and when the grain is formed, they take it off the fire to purify it.

The purifying is performed by letting it ftand in large ofier bafkets; where it drains itfelf of certain humidities that remained. When dry it is laid in heaps, and thence is carried into the magazines.

The commerce of falt has brought an immenfe profit to France, though more to the king than to the makers and fellers; on account of the heavy duty, which ufed to be one-fourth part of the price the falt was fold at. The Englifh and Dutch, and (when they are at war with France) the Swedes and Danes, have taken off moft of the falt of the Comte Nantois; paying for it, *communibus annis*, from 20 to 35 livres the load. That of Guerande has been preferred, by the Englifh and Irifh, to all the reft, as the beft. Yet that of Borneuf, though browner, and heavier, is moft ufed in France, as alfo throughout the Baltic; particularly in Poland, where, befides the ordinary ufes, it ferves in tilling the ground; being found to warm it, and prevent little vermin from gnawing the grain.

The Englifh and Dutch have often ftriven hard, in times of war, to do without the French falt; and to that end have endeavoured to take falt from the Spaniards and Portuguefe; but there is a difagreeable fharpnefs and ferofity natural to this falt, which renders it very unfit for the falting of flefh, fifh, &c. To remove this, they boil it with fea-water, and a little French falt, which they procure by means of neutral nations, which not only foftens it, but increafes its quantity by one-third. But it fhould feem their refining does not fucceed to their wifh, by the eagernefs with which they return to the falt of Bretagne, &c. as foon as any treaty has opened the commerce. See SALT-*Marfhes*.

In the fouth of France thefe works are carried to a great extent. The land generally deftined for this purpofe is flat, having a clayey foil, and not liable to inundations. It is furrounded by a wall or bank, having inlets next to the fea, capable of being opened and fhut at pleafure. The land thus allotted is divided into fields or compartments, of from fifty to one hundred acres. When the evaporation is fo far advanced that the falt begins to be depofited, it is pumped up on a platform elevated above the fields, for the purpofe of giving free accefs of air, by which the remaining water is evaporated. As the water evaporates more brine is pumped up, till the falt is formed into a cruft of about three inches in thicknefs. This platform is divided into many compartments, connected with each other by a common gutter. When the falt has become hard it is broken into pieces, and laid up in heaps, fheltered from the rain. It will be obvious, from what has been obferved of the Englifh falt extracted from fea-water, that this incrufted mafs muft contain a certain portion of thofe earthy falts which conftitute the *bittern*. This bitter fluid drains from the incrufted heaps for a long time, and the falt made in this way is not deemed perfectly good till it has been expofed for three years. In fome places thefe drainings are collected for the purpofe of procuring fulphate of magnefia, and other preparations containing magnefia. When falt is not freed from thefe deliquefcent falts, it is apt to become moift in the air, and has a difagreeable bitter tafte.

This falt is called *bay-falt*, and a prejudice has prevailed in its favour in moft countries, as poffeffing more valuable properties in preferving animal food. The valuable effay by Dr. Henry, to which we have before referred, deferves the greateft praife, inafmuch as it clearly proves that the foreign falt, fo far from being fuperior to the Chefhire falt, is very inferior to it in thofe points on which its preferving quality depends. This prejudiee has made us dependent upon France, Spain, and Portugal, for an article which we might with as good reafon export.

The following table is the refult of Dr. Henry's analyfis, which was conducted with great fkill, and with his ufual accuracy. It may be obferved here, that it is the opinion of feveral chemifts, that falt, and the bittern in which it is formed, contain fulphate of foda. From Dr. Henry's experiments this appears to be a miftake.

One Hundred Parts by Weight confift of

	Kinds of Salts.	Infoluble Matter.	Muriate of Lime.	Muriate of Magnefia.	Total earthy Muriates.	Sulphate of Lime.	Sulphate of Magnefia.	Total Sulphates.	Total Impurities.	Pure Muriate of Soda.
[illegible]gn B[illegible] wat	St. Ubes	9	a trace	3	3	23½	4½	28		960
	St. Martin's	12	ditto	3½	3½	19	6	25		959½
	Oleron	10	ditto			19½	4¼	23¾		964¼
[illegible]fhire Sal[illegible] Sea-	Scotch (common)	4		28 &c. +	28 &c. +	15	17½	32½		935½
	Scotch (Sunday)	1		11½	11½	12	4½	16½		971
	Lymington (common)	2		11 &c. +	11 &c. +	15	35	50		937
	Ditto (cat)	1		5	5	5	5	6		988
	Crufhed rock	10	$0\frac{1}{16}$	$0\frac{3}{16}$	0¼	6¼		6½		983[illegible]
	Fifhery	1		0¾	1	11		11¼		986[illegible]
	Common	1		0¾	1	14¼		14½		983[illegible]
	Stoved	1		0¾	1	15		15½		982[illegible]

The three firft fpecimens are of the foreign or bay-falt. In the column marked total quantity of impurities, it will be feen that they are not by any means fo pure as the four laft, which are the Chefhire falts. A large portion of their impurities, it will be feen by the fecond column, is infoluble matter, which is principally clay, derived from the platform on which it was evaporated, which is formed of wood, and plaiftered with clay to make it water-tight. The fulphate of lime is doubtlefs an ingredient of the fea-water. Perhaps the circumftance of the heaps of falt being left fo long to

drain out their deliquefcent falts, may account for their containing fo fmall a quantity of the muriates of lime and magnefia, and fulphate of magnefia.

Dr. Henry gives another reafon for the deficiency of the latter fubftances in bay-falt. The evaporation being very flow, the cryftals are much larger than thofe produced by artificial heat alone, which is the cafe with the Britifh fpecimens obtained from fea-water: and fince the deliquefcent falts can exift only upon the furface of the cryftals, it will be evident that the quantity contained in any falt, will be as the furface expofed, which will be as the number of cryftals in a given mafs, and inverfely as their fize.

This very clearly fhews why the bay-falt is lefs contaminated with the deliquefcent falts. The reafon why bay-falt contains more fulphate of lime than the Britifh, will be explained from the pains taken to remove the matter which is feparated while evaporating. The fulphate of lime, being fparingly foluble, is feparated in clearing the pan; and forms alfo a part of the incruftation at the bottom of the pan, called *fcratch* in the falt-works in the North, and *pan-fcale* in Chefhire. The Scotch common falt, for reafons above given, contains a large proportion of the deliquefcent falts, and of fulphate of magnefia. The evaporation is carried on rapidly; in confequence of which the cryftals are fmall, which gives a greater furface for the moift falt to adhere to.

The Sunday falt is fo called, from the fire being let out from Saturday night till Monday morning. The evaporation, by this means, is flower, and the cryftals larger, and in confequence prefents a lefs furface for the retention of the liquid impurities.

The Lymington common falt contains nearly the fame quantity of impurities with the Scotch common. But the quantity of fulphate of magnefia much exceeds the muriates. The quantity of impurities in the two varieties depends upon the fimilarity of their cryftals, with refpect to furface, the quality of each depending upon the fea-water from which it is obtained.

The cat-falt, of the formation of which we have before fpoken, is formed by a very flow cryftallization; hence its cryftals are large and fmooth on the furface; and hence, as will be feen in the table, it is the moft pure of all the varieties.

In the four laft, which are the Chefhire falts, it will be feen that the impurities differ much from thofe obtained from fea-water.

The crufhed rock-falt, exclufive of its infoluble matter, would be nearly pure. This impurity is, doubtlefs, fimilar to that feparated in cleaning the pan, *viz* carbonate of lime and oxyd of iron. The remainder is fulphate of lime, a fubftance generally exifting plentifully in the fame ftratum which contains the rock-falt. The other fpecimens have little infoluble matter, the impurity confifting chiefly of fulphate of lime, which becomes precipitated with the cryftals of the falt as the evaporation goes on. Dr. Henry, with his ufual fagacity, conjectured that the fulphate of lime would be the moft abundant in the falt which firft falls to the bottom, and the leaft in the laft portions. This he found to be the fact.

		Sulphate of Lime.
The common falt, drawn out two hours after the heat was applied - -	contained in 1000 parts	16
Salt drawn four hours after - -		11
Salt drawn fix hours after - -		$3\frac{1}{2}$

He alfo properly obferves, at the fame time, that the impurities derived from the foluble falts will be the leaft in the firft falt which falls down, and the greateft in the laft.

Inafmuch as the fmallnefs of the cryftals is favourable to the concealment of the foluble impurities, it is alfo the caufe of this falt not being fo well fitted for falting provifions which require merely to be ftratified with the falt. The fluids which proceed from the animal matter tend to diffolve the falt, and the folution will go on more flowly as the cryftals are larger; becaufe the furface is lefs. By this means the falt is more completely infinuated, and in confequence more effective. From this reafoning Dr. Henry concludes, that falt in large grains or cryftals is beft fitted for the ftratifying mode of falting, and fmall falt better adapted for making brine or pickle, in which the fubftance is immerged.

This view of the fubject may fuggeft fome reafon why a preference has been given to the foreign bay-falt. For, although it is not fo pure as the Chefhire common falt; yet, from the flow way in which it is evaporated, the cryftals are larger, and in confequence poffefs the advantage above ftated. The large-grained fifhery-falt, however, is certainly fuperior to the bay-falt for the ftratifying method of falting. Indeed, its name feems to have arifen out of its own celebrity; and it is no uncommon practice for this falt to be fold as bay-falt. In all falt-works thefe hints may be turned to fome account, particularly in the manufacture of fifhery-falt. By a more protracted evaporation, the cryftals will be larger, which has two advantages in that made from fea-water:—the falt will contain lefs of the foluble impurities, which are the muriates of lime and magnefia, and fulphate of magnefia; and it will be as well fitted for all purpofes as the foreign falt, the importation of which is a national evil, and a difgrace to thofe who prefer it to our own large-grained falt.

Salt *upon Salt*, a kind of common falt prepared by the Dutch, of great ufe in preferving herrings and other fifh, and to which they principally owe their advantages in the herring-trade. The Dutch prepare two kinds of refined falt, one of a fmall grain, intended for the ufe of the table, and called butter falt. They export large quantities of this to the countries upon the Rhine, and into other parts of Germany. The other kind is a very ftrong and pure falt, and is of the largeft grain of any boiled falt now made: this laft they call the St. Ubes's or Lifbon falt, from its refemblance to the pure bay-falt made in thofe places.

The falt which they refine is altogether marine bay-falt, and they chiefly have it from France and Spain; but they find, by experience, that any one kind of bay-falt does not anfwer their purpofes fo well as two or more kinds; they therefore frequently mix three parts of Cadiz falt with one part of that of Soufton, which is of great ftrength, but very dirty, and of a green colour, and does not coft above half the price of the Spanifh falt: for diffolving the bay-falt they ufe fea-water, which they bring in lighters to Dort and Rotterdam from below the Brill or Helvoet; out of thefe lighters it is craned into cellars, and is thus impregnated with bay-falt to a certain degree of ftrength, which they determine by hydrometers made for that purpofe. After the heavy drofs of the falt is fubfided at the bottom of the cellar, the clear brine is pumped up into the falt-pan through a mat, which retains the light fcum, ftraws, or other impurities, which floated on the furface of it. Thefe falt-pans are of iron, of a round figure, and commonly forty feet in diameter, and eighteen inches deep. Thefe pans are placed over a hearth-furnace, and the only fuel they ufe in boiling the falt is dry turf. The fire is kept up fo high, that the liquor boils brifkly all the time, and if any fcum arifes, they carefully take it off, but

they ufe no clarifying mixtures. A little before the falt begins to granulate, they add to the pan a lump of butter, of the bignefs of a walnut, and half a pint of four whey, which has ftood at leaft half a year. This acid whey, called *azy*, unites itfelf with the uncombined fixed alkali contained in the falt, and thus prevents it from adhering to the common falt as it cryftallizes. Any other mild acid might probably anfwer the fame purpofe. When thefe things are perfectly mixed in by a good ftirring, they fhut the doors and windows of the houfe, that no air may blow in cold, and the houfe is kept thus hot all the time that the falt is forming. This method is not new or peculiar to the Dutch works, for Agricola defcribes an apparatus of boards to keep the cold air out of the falt-pan all the time that the falt is forming; and the Germans ufe it, in many places, at this time.

It is out of this fame brine, and by the fame procefs, that they make the table-falt and the ftrong falt; only towards the end of the procefs they make this difference; if the pan is to be wrought into table-falt, the brine is kept gently fimmering during the whole operation, and all is finifhed in twenty-four hours; but if it be to be made into a ftrong falt, they flacken the fire to fuch a degree, that the operation takes up three days. In both cafes they let the falt remain in the pan till the whole is finifhed; they then rake it out with wooden rakes, and after it has drained a-while in wooden drabs, it is fit for ufe. The mother-brine, of which there always remains a large quantity in the pan after the ftrong falt is made, as alfo the drainings of the drabs where the falt is put, is referved to be boiled up into table-falt; but the mother-brine of table-falt becomes more fharp and bitter after every procefs, and is finally thrown away.

The principal ufes to which falt is applied, are as a feafoning in our food, in the making of butter and cheefe, the curing of hams, bacon, and fifh, and the prefervation of animal and other fubftances. For the firft of thefe purpofes it feems almoft an indifpenfable neceffary, fo infipid would be moft kinds of food without it. It is remarked, with fome truth, that its flavour is agreeable to moft other animals as well as man. There are places in America where the fea occafionally overflows, which, on the water evaporating, leaves the falt. Thefe places are called *licks*, and are the refort of vaft crowds of different quadrupeds, whofe object is to lick the ground for the fake of the falt. It is faid that hay, fprinkled with falt, is eaten by cattle with greater avidity. Salt has been faid to be injurious to health when taken in more than common quantity. It would, however, be difficult to mark out any inconvenience in thofe who take more than is generally taken. Each perfon acquires the habit of a certain dofe in his food, above or below which he would feel great inconvenience in taking it. Some countries far removed from the fea, and having no fupply from the mineral falt, are obliged to extract it from the afhes of certain vegetables. In fome places it is fo valued from its fcarcity, as to become a fubftitute for coin. In fome of the northern countries, where fuel is fcarce, the fea-water is let into ditches lined with clay, and the water, on freezing, concentrates the falt in the remaining fluid, which, being faturated, requires lefs evaporation. The ufe of falt in preferving food is found to have fome difadvantages. Although it preferves the food, it ultimately changes its nature, and deftroys its nutritious qualities. We have ftriking inftances of thefe effects in the fea-fcurvy, which is not produced by the falt in the meat, but from its being deprived of its nutritive qualities and rendered indigeftible. Pickles or vats made with fugar, nitre, and a little falt, are faid to preferve meat better, without injuring its quality.

Sir Humphrey Davy fuppofes that the power of falt in preferving animal and vegetable fubftances is owing to its attraction for water, by which the decompofing action of that fluid is prevented, as well as to its power of excluding air. And Dr. Holland, who feems to have attended much to the fubject, thinks, that although the different forts of this fubftance differ little in their nature or purity in confequence of the manner in which they are made, it may readily be conceived, that their difference in form, as well as compactnefs, may fit them for very various applications in thefe intentions, efpecially in the prefervation of animal flefh and provifions. But in every cafe, the more pure the falt is, and the more free from any admixture of foreign alkaline or earthy faline matter, the more effectual it will be for the purpofe it is defigned. Thus it is fuppofed by the writer juft mentioned, that for table ufe, the falting of butter, and various domeftic purpofes, a preference fhould be given to the finer kind of falt, or that which is prepared by a boiling heat; as the fmallnefs of its grain fits it in a better manner for all fuch applications. It is alfo better for the making and preferving of cheefe; and in that procefs, as well as in the making and preferving of butter, it is particularly proper, in confequence of its blending, incorporating, and uniting itfelf in fo equal and intimate a manner with the different fubftances. It may likewife be the moft proper for preferving different kinds of vegetable fubftances on the fame account.

For the like reafon of the fmallnefs of its grain or particles, as well as from its confequent readinefs of folution, the fame fort of falt may, it is faid, be well, or perhaps the beft adapted of any for making the pickle for *ftriking* the meat, which, with the rubbing it well on and into the fubftance, for which fuch a ftate of its parts admirably fits it, is the primary proceeding in the preferving of animal flefh, and the firft part of the procefs in the curing of fifh in the fifheries, or in other ways and intentions.

But it is contended, that for the purpofe of *packing* fifh and provifions of the meat kind, it is by no means fo proper, or fo well fitted and efficacious, as the common or large-grained fifhery-falt; for, as might be expected, it is found, when applied to this purpofe, not to preferve them in an equally effectual manner from taking on or running into the ftate of putrefaction. This, however, is ftated to arife, not from any want of purity in the falt, or from any admixture of earthy falts or other matters with it; but from the fmallnefs of its grain or particles, and its want of hardnefs and compactnefs, originating from the circumftance of its containing a larger proportion of the water of cryftallization than the larger grained falt. Therefore, in confequence of its being fo ready of folution, the whole of it is formed into brine; which, it is thought, by being forced out from betwixt the layers of flefh or fifh, by the preffure of thefe on each other, the different portions of animal matter are allowed to come into clofe contact, without having any falt interpofed. Whereas, on the contrary, when the falt of a larger grain is employed, a confiderable part of it continues long undiffolved; feparating the different layers or portions of meat; admitting in fome degree the brine to flow and infinuate itfelf betwixt them; and furnifhing a conftant new fupply of faturated brine, from the gradual folution of the falt in the fluids exuding from the animal matter, to every part of the packed provifions or other matters.

And it is further fuggefted, that the action or operation of bay-falt in the fame intention, is exactly fimilar to that of the large-grained falt; and that neither the one nor the other would feem to have any fuperiority or advantage

over the fine falt prepared by a boiling heat, except in fo far as the fize and compactnefs of its cryftals are concerned; and in containing a fomewhat fmaller proportion of the water of cryftallization. And that, as the large-grained fifhery-falt, which is prepared by a low degree of heat from natural brine, is, it is thought, more than equal to the bay-falt in thefe important points; there can be no doubt, whatever prejudices to the contrary may have exifted, or have been formed on the matter, that it at leaft equals the latter in its power of preferving animal flefh, or provifions, and perhaps other fubftances.

As experience, however, has much more weight than any theory or opinion on fuch a fubject as the prefent, the writer has had recourfe to it in fupport of his reafoning on the matter. This fort of experience is had, it is faid, on an extenfive fcale, at the victualling-office near Deptford, at which, it is ftated, the large-grained falt manufactured in this country from natural falt-brine fprings, has for feveral years been the only falt ufed for packing provifions, after they have been firft falted or cured with common falt, or that which is prepared by a heat of one hundred and eighty degrees. And it is afferted, that though thefe provifions have been afterwards carried to the hotteft climates, the ftrength and purity of the falt employed in preferving them have never been called in queftion. They have kept perfectly well, and it has never been doubted that the falt ufed there, was in every refpect equal to the St. Ubes' falt; or to any other falt prepared from fea-water, by the natural heat of the fun. It is remarked, that what is fold in the metropolis as bay-falt, is almoft wholly the large-grained falt of home manufacture from natural brine-fprings or others of the fame quality.

However, ftrongly rooted prejudices in favour of bay-falt in the prefervation of meat and fifh ftill exift in Ireland, Scotland, and perhaps in fome parts of this country, which cannot be removed, except by fome change in the duties of the foreign or imported falt, and that which is made in this country, by which the latter may be fold at a much lower rate than the former. And fuch a regulation would feem defirable, as large fums are now annually paid for bay-falt, which might be faved to the country without any difadvantage.

The ftate and form of falt, as the confequence of the method of preparing it, are therefore conftantly to be confidered in the rural and other practices of curing meat and other fubftances. See SALT-*Brine Springs*.

It has been fuggefted by the firft of the above writers, that where animal or vegetable food is to be preferved on a large fcale, he is difpofed to believe that it may be in fome meafure effected by forcibly throwing a quantity of carbonic acid, hydrogen, or azote, into the veffel, by means of a compreffing pump, fimilar to that contrived for making artificial Seltzer water. In this way any change in the fubftances would, it is thought, be more effectually prevented. And no elaftic fluid would, in fuch cafes, have room to form by the decompofition of fuch matters; befides, the tightnefs and ftrength of the veffel would be proved by the procefs. That as no putrefaction or fermentation can go on without the production of elaftic fluid; preffure would probably act with as much effect as cold in preferving thefe forts of provifions.

With regard to alimentary falt in general, we may obferve, that though it appears to us under various forms, it is immediately diftinguifhed by applying it to the tongue, and its always affuming the fame figures after a regular cryftallization. Its cryftals are cubes, feveral of which unite together into the form of hollow truncated pyramids.

Common falt diffolves in water, and cold water diffolves nearly the fame quantity as hot boiling water, nor does it concrete again in the cold, like the other neutral falts, as long as the evaporation of the fluid is prevented; but writers are not agreed about the proportion of falt diffolved in water. Some fay, that it diffolves in lefs than thrice its weight of boiling water; others fay, that it requires 3⅐th times its own quantity of water; and others again fay, that four parts of water to one of falt are required for a perfect folution. Thefe differences may be eafily accounted for by the different falts that may have been ufed. Boerhaave is of opinion, that 16 ounces of water will not diffolve quite five ounces of rock-falt; Spielmann, with whom Neumann agrees, thinks that they will diffolve 6⅔d ounces; Eller fays, that feven ounces of foffile falt may be diffolved in 16 ounces of water; and Hoffmann affures us, that 16 ounces of water will not diffolve above fix ounces of common falt. Dr. Watfon's experiments confirm that of Hoffmann; for he obferves, that he never could diffolve quite fix ounces of rock-falt in 16 ounces of water. The fea-water in different parts of the world is very differently fated with falt; that of fome parts containing twice as much as others. The fea-water which furrounds the coafts of Great Britain, is faid to hold feldom more than one-thirtieth, or lefs than one-fiftieth part of common falt. When water is impregnated with any falt, as much as it can bear, it will ftill diffolve a quantity of another falt, whofe particles are of different figures, proper to infinuate into the remaining vacuities of the water: thus, after common falt will no longer diffolve in it, alum will; and after alum, faltpetre; then fal ammoniac, &c.

Although common falt is very cryftallizable, and exactly neutral, it very readily becomes moift when expofed to humid air, and muft, therefore, be kept in dry places. This falt contracts an union with common falt with a calcareous bafis, and, confequently, all the falt obtained either from fea-water, or falt fountains, contains a certain quantity of this falt with earthy bafes, the white earth of which will precipitate by adding fixed alkali to a folution of common falt in pure water. In order to obtain a very pure common falt, it is neceffary to diffolve it in water, filtrate it, and add a folution of cryftals of foda, or marine alkali, till no more white cloud is formed by the addition; then filtrate the liquor again, and evaporate it.

The cryftals of common falt, expofed to the fire, crackle and burft, and thus form the *fal decrepitatum*, foon after melt, and when cool, fix in form of a white and almoft opaque mafs. This falt is abfolutely unalterable by fire, even when it has been heated ftrongly together with inflammable matters; a property which refults from the flight difpofition which its acid has to combine with phlogifton, as the experiments of Meffrs. Duhamel and Margraaf have demonftrated. However, though it be fixed in the fire to a certain degree, yet when it is expofed to a violent fire with free accefs of air, it exhales in vapours, and attaches itfelf in white flowers to bodies lefs hot than itfelf. Chemifts know no other acid but vitriolic and nitrous acids, and fedative falt, which can decompofe common falt by difengaging its acid.

Common falt is of all faline fubftances the moft neceffary and ufeful. Its acid and alkali are employed in many chemical operations in the arts; it is an important ingredient in the fufion of glafs (fee GLASS), which it whitens and purifies; it facilitates the fufion and precipitation of the metallic parts of minerals in affays, and perfectly covers them; and its peculiar ufe in preferving meats, &c. feafoned with it, or fteeped in folutions of it, and in improving the

taste of aliments, is universally known, and has been already mentioned. In the application of salt to this important purpose, it retards and prevents the putrefaction of almost all our aliments, without producing any such change upon them, even when preserved a long time, as to render them altogether unfit for nourishment. And though salted animal foods are generally accounted one of the principal causes of the scurvy at sea, this is owing not to the salt itself being prejudicial, but to its being incapable of preserving the animal subjects, for a length of time, in a perfectly uncorrupted state. Pure sea-salt, and sea-water, are rather salubrious than hurtful, both in the true *scurvy*, (which see,) and in impurities of the blood and humours in general.

Hoffmann observes, that an ounce of the salt, dissolved in a proper quantity of water, occasions commonly six stools or more, without uneasiness; that this salt checks the operation of emetics, and carries them off by stool; that in glysters it is more effectual, though used only in the quantity of a drachm, than any of the purgatives; and that where other glysters fail of opening the belly, a solution of common salt produces effect.

With regard to the antiseptic property of common salt, it is proved by the experiments of sir John Pringle, Dr. Macbride, and M. Gardane, in his Essay towards a History of Putrefaction, that, though when mixed with animal substances in a large proportion, it preserves them from putrefaction, yet when a small quantity of it is employed, it considerably accelerates putrefaction. Whence it appears, that small quantities of common salt, such as are taken with food, facilitate digestion, which is a kind of incipient putrefaction, and serve at the same time as a mild stimulus to the stomach itself: and, therefore, common salt is not only agreeable and useful, but also salutary, at least to all constitutions in which the digestion is too remote from putrefaction, as in those which are properly called crudities; though different temperaments may differ much in this respect. Common salt is observed to differ from other saline substances, in occasioning drought, and tending, not to cool, but rather to heat the body. Lewis's Mat. Med. and Macquer's Dict. Chem. Eng. ed. art. *Common* SALT.

SALT, *Common, Laws relating to.* By 38 Geo. III. c. 89. the management of the salt duties is transferred to the commissioners of excise; and by 43 Geo. III. c. 69. 45 Geo. III. c. 14. and 47 Geo. III. sess. 2. c. 30. several duties are imposed upon it; and by the last act the additional duties charged by that and the preceding are charged upon Glauber and Epsom salts. And 65 pounds weight avoirdupois of rock-salt shall be deemed a bushel, and 56 pounds of every other kind of salt. (38 Geo. III. c. 39. s. 4. 45 Geo. III. c. 14. s. 4.) The act 47 Geo. III. sess. 2. c. 30. recites the provisions previously made for imposing duties on salt as follows: By 43 Geo. III. c. 69. a duty of 10*s.* is imposed for every bushel of salt and rock-salt made at any salt-work or taken out of any mine in England, and a duty of 4*s.* for every bushel of the same in Scotland; and by 45 Geo. III. c. 14. an additional duty of 5*s.* for every bushel (as above) in England for home consumption, and 2*s.* in the same manner in Scotland. By the former act an allowance is directed to be made of 10*s.* for every bushel of salt of English manufacture, used by any bleacher of linen or cotton in England, in the making of oxygenated muriatic acid for this purpose, and so in proportion for any greater or less quantity, deducting at the rate of $7\frac{1}{2}$ *per cent.* in consequence of the increase in the weight of the salt by the moisture of the air, and an allowance of 4*s.* for every bushel of salt used for the same purpose in Scotland, with a similar deduction: and by the 47 Geo. III. sess. 2. c. 30. a farther allowance on salt used by bleachers in making oxygenated muriatic acid, out of the duties imposed by 45 Geo. III. c. 14. of 5*s.* for every bushel of salt of English manufacture, consumed in England, and with the deduction above stated, and 2*s.* on every bushel consumed in Scotland for the same purpose, and subject to the same deduction.

The act 43 Geo. III. c. 69. imposes a duty of 13*s.* 4*d.* for every bushel of salt imported into Great Britain, not being Irish salt imported directly from Ireland; for every ton of rock-salt, which shall be exported to parts beyond the seas, other than Ireland, 1*d.*; for every bushel of salt or rock-salt brought from Scotland into England, with a certificate that the duty of 4*s.* has been paid, 6*s.*; and for every bushel of salt employed in curing and salting fish, exported from Scotland to England, 6*s.*; and for every cwt. of salted beef or pork, or bacon, brought by land from Scotland to England, 2*s.* 6*d.* The said act allows drawbacks of 10*s.* for every bushel of salt made in England, rock-salt excepted, for which all the duties have been paid, and duly exported; of 4*s.* for every bushel of salt made in Scotland, similarly circumstanced; and of 10*s.* for every bushel of Glauber or Epsom salts. By 45 Geo. III. c. 14. an additional duty of 6*s.* 8*d.* is imposed on every bushel of salt imported into Great Britain (not being Irish salt imported directly from Ireland); for every bushel of Irish salt or Irish rock-salt, or Irish Glauber or Epsom salt, imported into Great Britain, an additional duty of 5*s.*; and by the same act the following drawbacks are allowed, *viz.* for every bushel of English salt (rock-salt excepted) duly exported, 5*s.*; and for every bushel of Glauber or Epsom salt, made in Great Britain, duly exported, for which the duties have been paid, 5*s.*; and for every bushel of salt made in Scotland (rock-salt excepted) in the same circumstances, 2*s.*

But the duty imposed by this act shall not extend to any foreign or British salt delivered or received for the sole purpose of curing or preserving fish. By 47 Geo. III. sess. 2. c. 30. 6*d.* of the duty of 2*s.* 6*d.* *per* cwt. (under 43 Geo. III. c. 69.) on salted beef or pork, or bacon, brought by land from Scotland to England, shall cease.

Commissioners may compound for the duty with the refiners of rock-salt, and also for the duty on mineral alkali or flux for glass. (45 Geo. III. c. 14. s. 7.) The importer of foreign salt shall pay the duty upon entry, and before landing, under the penalty of forfeiture of the said salt, and all vessels, horses, carriages, &c. employed in removing, landing, or conveying the same, which may be seized by any officer of excise or customs; and every person employed, or to whose house the salt shall come after having been unshipped, knowing the same, shall forfeit treble its value: s. 8. If any salt be imported without entry and payment of the duty, within 20 days, such salt shall be forfeited, and may be seized: s. 9. Provided nevertheless, that such foreign salt, not less than 50 bushels, upon entry and before payment of the duty, may be landed in presence of an officer, weighed and warehoused upon bond being given in double the amount of the duty, to pay and clear off the duty when sold, if within 12 months, and if not sold within that time, then at the end of such 12 months: s. 10. The warehouses are to be secured under the joint locks of the officer and proprietor; nor shall any salt be put into or taken out of such warehouse in less quantity than 50 bushels, at one time, and after proper notice of 12 hours, and with the attendance of an officer: s. 11. No foreign salt shall be imported in any vessel of less burden than 40 tons, except for the use of the seamen, not exceeding 5lbs. for each man, upon pain of forfeiting such salt and

vessel, &c. s. 13. No salt shall be imported from Ireland, Guernsey, Jersey, Sark, Alderney or Man, except for the use of seamen, not exceeding 2lbs. for each man, and is liable to forfeiture with the vessels, and may be seized; but fishing vessels, having a due quantity of salt, received from entered warehouses, or other vessels employed in fishing, are exempted: s. 14. By 45 Geo. III. c. 14. s. 19. no salt shall be imported from Ireland into Great Britain in any ship of less burden than 100 tons, under penalty of the forfeiture of salt, vessel, &c.: and by s. 10 and 11, if any person shall put on board any vessel in Ireland more than in the proportion of 2lbs. of salt for each person employed in the ship, without notice and bond, he shall forfeit all such salt, and 100*l.* By s. 14. no rock-salt shall be refined, or made into white salt, at any place in Great Britain beyond the distance of ten miles from the salt-mine or salt-pit from which the rock-salt has been taken; except at such works as have been duly entered for the purpose one year previous to the passing of this act: and places for making salt in England are to be entered, on pain of forfeiting 100*l.*, the salt, and articles used in making the same, &c. s. 17. By 38 Geo. III. c. 89. officers may enter and take an account at any time by day or night. Proprietors are to provide warehouses and store their rock-salt in them, &c. under penalty of 100*l.* s. 19. Proprietors are to give notice of their intention to take salt out of the mine, under forfeiture for every offence of 20*l.* No rock-salt shall be taken out of such warehouse, but in the presence of an officer, no less than four bushels at a time, and between the hours of five in the morning and seven in the evening from March 24th to the 29th of September; and between seven in the morning and five in the evening from 28th September to 28th March, in each year, under penalty of forfeiture of salt, &c. and 40*s.* for every bushel of such salt, or 50*l.* at the election of the attorney-general, or person who shall sue: s. 21. Makers and refiners of salt shall provide suitable warehouses, with proper fastenings, which shall be kept locked, except when the officer attends, under forfeiture of 50*l.* s. 22. Such maker shall give six hours' notice in writing before he begins to charge any pan or boiler, which notice shall specify whether he intends to make larger grained, commonly called fishery-salt, or fine-grained salt, under penalty of 20*l.* for each offence: s. 23. And he shall proceed without delay, on pain of 20*l.* Brine may be added once and no more: s. 24. But the whole operation must be finished before fresh brine is put in, under penalty of 50*l.* s. 25. The salt taken from each pan is to be kept separate, and within ten hours after it has been taken out, the maker shall specify in writing to the proper officer the quantity made at such boiling; and when the officer has taken account of it, all such salt shall be removed into the maker's entered warehouse, on pain of 20*l.* Half the salt of one boiling may be warehoused before the whole is finished, nor is any salt to be warehoused till an account is taken, under forfeiture of 20*s.* for every pound, or 100*l.* at the option of the attorney-general, or the person suing: s. 30. Salt may be removed to warehouses at Liverpool or Bristol for the purpose of exportation; and bond shall be given, which bond shall be discharged, upon leaving with the proper officer, within three months, a certificate that such salt was duly delivered and secured at such warehouse: s. 33. 70, 71. The salt removed to export warehouses may be immediately shipped, without being warehoused, and the bond be discharged: s. 72. Salt shall not be removed out of warehouses, except at stipulated times, under penalty of forfeiting the same, carriages, horses, &c. and 100*l.* for every such offence: s. 34. Salt shall not be removed without a permit, under the penalty of forfeiting as before, and 40*s.* for every pound, or 100*l.* at the pleasure of the attorney-general, or person who shall sue: s. 35. Persons removing salt without a permit shall on conviction forfeit 50*l.* or be committed to the house of correction for any time not exceeding 12 months: s. 36. Warehouses are to be approved by the officer, and repaired or altered according to his directions; and if such warehouses be opened or entered by any person but in the presence of the officer, he shall for every offence forfeit 20*l.* s. 37, 38. And if any lock or fastening provided by the officer at the expence of the proprietor be removed or broken, the delinquent shall forfeit for every such offence 100*l.* s. 39. And it shall be repaired by the proprietor within a reasonable time, on pain of forfeiting 20*l.* s. 40. Notice is to be given when it is proposed to take salt out of the warehouses, and the officer is to attend. The proprietor shall be discharged from payment of duty for rock-salt taken out for refining, for exportation, or for curing of fish: s. 41. Rock-salt may be made into white salt at the appointed place, and no other, under forfeiture of 200*l.* s. 15 and 16. (45 Geo. III. c. 14. s. 14.) Permits shall be granted upon application by a note in writing: s. 43. The permit shall be returned after the time limited on demand, on pain of forfeiting 50*l.* for every offence; and giving false permits incurs a penalty of 500*l.* for every such offence: s. 104. s. 132. Duties shall be cleared off within a week after entry, or bond be given in double value: s. 45, 46. Removing rock-salt without a permit incurs a forfeiture of the same, and carriages, cattle, &c. and persons concerned in so doing incur a penalty of 500*l.* s. 48. Scales and weights are to be provided by the proprietor, and his servants are required to assist, on forfeiture of 100*l.* s. 50, 51. He that conceals salt to evade the duty forfeits the salt and 50*l.* s. 52. Officers may seize salt found in vessels and carriages suspected of being clandestinely removed, and persons offending shall forfeit the salt and carriages, &c. and 40*s.* for every pound weight: s. 54. The proof of payment of duty lies on the owner, and not on the officer who seized the same: s. 56. Previous notice is to be given of shipping salt for exportation, and bond shall be given in treble the value for payment of the duty, for the due exportation, and that it shall not be relanded in Great Britain. Salt for curing fish may be imported, and must be duly entered: s. 12. Before such salt is delivered duty free, bond in double the amount of the duty shall be given that such salt shall be delivered to the fish curer, &c. The rates at which salt for curing fish shall be allowed are as follow:

For every hundred weight of cod, ling, or hake, 50 pounds of salt.

For every barrel containing 32 gallons of wet cod, ling, or hake, 56 pounds of salt.

For ditto 42 gallons of salmon, 36 pounds of salt.

For ditto 32 gallons of white herrings, 140 pounds of salt.

For every barrel containing 32 gallons of red herrings, 65 pounds of salt.

For ditto 32 gallons of clean shotten red herrings, 56 pounds of salt.

For every last consisting of 1000 dried red sprats, 25 pounds of salt.

For every cask containing 50 gallons of pilchards or scads, 336 pounds of salt. 42 Geo. III. c. 93. s. 20.

For 32 gallons of mackarel, 84 pounds of salt.

And so in proportion for any greater or less quantity.

No salt shall be used in curing pilchards or scads more than twice; and in taking account of salt only once so used, credit shall be given to every fish curer for such salt, as containing of pure salt in the proportion of three parts in four

of the whole quantity and no more; and every officer of excise shall make his computation according to such proportion. 42 Geo. III. c. 93. s. 21.

And every barrel, cask, or vessel, in which fish, beef, or pork, entitled to any bounty shall be packed, shall be gauged according to the gallon English wine measure. 38 Geo. III. c. 89. s. 5.

All salt imported from Scotland without a legal permit testifying that all the duties payable in Scotland have been paid shall be forfeited, together with the packages, ships, boats, and other vessels, waggons, carts, and other carriages, horses and cattle employed in removing the same, which may be seized by any such officer; and the person in whose custody such salt shall be found, or employed in removing the same, shall forfeit 50*l*. s. 86.

No salt shall be removed from Scotland to England by land, on pain of forfeiting the same, together with the packages, waggons, carts, carriages, horses and cattle employed in removing thereof, which may be seized by any such officer; and every person concerned in removing the same, contrary to the directions of this act, shall forfeit 40*s*. for every pound weight thereof, or 100*l*. at the election of the attorney-general, or person who shall sue. s. 87.

By 49 Geo. III. c. 81. salted beef, pork, or bacon, brought by land from Scotland to England, shall immediately on the arrival thereof in England, be entered at the nearest excise-office in England; on pain of forfeiting the same.

Every maker of glass may take rock-salt from any warehouse belonging to any salt-mine, or brine or sea-water for making mineral alkali, or flux for glass, upon bond being given that the same shall be so employed; such bond to be discharged upon oath being made before the collector that all such rock-salt, brine, or sea-water, for which the same was given, was made use of in making such mineral alkali or flux for glass, and for no other purpose whatsoever. s. 116.

Every person before he begins to make mineral alkali or flux for glass, shall make entry in writing of every work-house, warehouse, storehouse, room, or other place, and also of every utensil or vessel by him intended to be used therein, at the excise-office of the district. And if any such person shall begin to make any mineral alkali or flux for glass, without making such entry, he shall forfeit 100*l*. together with the same, and all materials proper for making the same, together with the utensils and vessels used therein, found in any unentered place. s. 117.

No such rock-salt shall be delivered out of such entered warehouse, for the purpose of making mineral alkali or flux for glass, or shall be afterwards delivered at such alkali works, or be deposited in any warehouse or place belonging thereto, but in the presence of an officer, who shall make an entry in writing, containing the weight or quantity thereof, and the day when so delivered, and the name of the maker of glass to whom delivered, and for the use of what works. s. 119.

In case the rock-salt so brought to be stored in any such alkali works, shall be less in weight or quantity than specified in the permit, the maker for whose use the same was delivered shall be answerable for the same. s. 120.

If any such maker, on whose account such rock-salt shall have been delivered as aforesaid, or if any other person shall use the same or any part thereof, or any acid materials to be produced therefrom, after being used in making such mineral alkali or flux for glass as aforesaid for any other purpose, he shall forfeit 100*l*. s. 121.

Any officer of excise may enter any such work-house or place made use of by any such manufacturer of mineral alkali or flux for glass, and if such manufacturer shall upon demand in the day time (and if in the night, in the presence of a constable or other peace officer) refuse to permit such officer to enter, he shall forfeit 50*l*. s. 122.

Provided always, that nothing herein shall extend to impose any duty on such Glauber salts as shall be made by any glass-maker in any of the processes of making mineral alkali or flux for glass, and which shall be *bonâ fide* expended and consumed in making such mineral alkali or flux for glass: s. 123. See however 47 Geo. III. sess. 2. c. 30. s. 2.

And whereas salt is an essential ingredient in making oxygenated muriatic acid used for bleaching linen and cotton, and allowing a drawback on salt used for that purpose would promote the manufacture thereof, it is enacted that the whole duties now payable on salt of British manufacture shall be drawn back for all salt consumed in making any such oxygenated muriatic acid as aforesaid. Provided, that no such drawback shall be granted for more or other salt than shall be mixed with vitriolic acid, manganese, and water, in the presence of an officer, and in the proportion of at least 20 pounds of vitriolic acid, 20 pounds of manganese, and 10 pounds of water to every 56 pounds of salt. Nor shall any such drawback be granted to any person not being a bleacher of linen or cotton, nor unless he make entry in writing of every work-house or place intended to be used in making such oxygenated muriatic acid as aforesaid at the next excise-office. Provided also, that any officer of excise may at all times, by day or night, upon request enter into any such work-house or other place used by such bleacher, and by weighing, gauging, or otherwise, take an account of all salt therein, and of the state of operation of such oxygenated muriatic acid. s. 89.

By 47 Geo. III. sess. 2. c. 30. s. 1. divers allowances are further made on salt used by bleachers in making such acid.

In all cases where it shall be necessary to ascertain the value of salt, the same shall be taken at the highest price at which the same shall sell for in London. s. 129.

If any person shall counterfeit or forge, or cause to be done, any certificate or debenture, with intent to defraud his majesty, he shall be guilty of felony, and be transported for seven years. s. 131.

If any person shall obstruct any officer in the due execution of his office, or shall by force rescue, or attempt to rescue, any salt, vessel, boat, horse, cattle, cart, or carriage, he shall for every such offence, for which no penalty is particularly provided by this act, forfeit 200*l*. s. 133.

If any person shall offer or give any bribe to any such officer, in order to corrupt him in the execution of his office, or to connive at or conceal any fraud relating to the duties on salt, whether such proposal be accepted or not, he shall forfeit 500*l*. s. 134.

And all fines, penalties, and forfeitures hereby imposed relating to the duties on salt, may be sued for, recovered, levied, and mitigated as by the laws of excise, or in the courts of Westminster, and shall be applied half to the king (except where otherwise expressed), and the other half to him who shall sue. s. 136.

Provided, that nothing in this act contained shall extend to repeal or alter any act in force relating to the duties on salt, immediately before the passing of this act, except so far as the same is revoked or altered or repugnant thereto, but all the provisions, regulations, penalties, and forfeitures thereby imposed (except as aforesaid) shall remain in full force. s. 140.

And all powers of 12 Car. II. c. 24. shall extend to this act. s. 142.

And the lord mayor and aldermen of London, and the justices of the peace, at their respective general sessions, may set, ascertain, and publish the price of salt to be sold or exposed to sale (and not intended for exportation) within their respective counties, cities, and places, and may alter the same as they may see occasion; and the prices so set or altered are to be observed by every person selling or exposing salt for sale. And if any person shall sell any salt (except for exportation) at any higher price, or refuse to sell it at the price so fixed as aforesaid, he shall forfeit 20*l.* to be levied by distress, by warrant of one justice; and in default of sufficient distress, such justice may imprison such offender until he shall pay the same, to be applied half to the king, and half to him who shall sue. s. 143. Burn's Justice, art. *Excise.*

There is a custom duty in the city of London, called "granage," payable to the lord mayor, &c. for salt brought to the port of London, being the twentieth part.

Salt, *as manure, and for the use of animals,* in *Agriculture,* is a substance which has been said to be found useful, when applied in this way to land, and as food or condiment in the support or fattening of domestic animals. In the former of these applications, there has been much difference of opinion in respect to its effects; some contending that it is highly beneficial; while others think that it is of little, if any, advantage. There are likewise others who have supposed it to be useful, when laid on land in small proportions, while in large ones it has an injurious effect; having, in the former case, a tendency to promote putrefaction; while, in the latter, it may retard it by its antiseptic property, as well as be capable of acting in other ways, in both cases. It has also been supposed to produce much benefit by the power which it possesses of destroying snails, grubs, and other similar animals that may be in the ground. It is observed by Dr. Darwin, that as it is a stimulus which possesses no nourishment, but may excite the vegetable absorbent vessels into greater action than usual, it may, in a certain quantity, increase their growth, by their taking up more nourishment in a given time, and performing their circulations and secretions with greater energy. In a greater quantity, its stimulus may be so great as to act as an immediate poison on vegetables, and destroy the motions of the vessels, by exhausting their irritability. And it has been remarked by the Rev. Mr. Cartwright, in an able paper in the fourth volume of the Communications to the Board of Agriculture, that at present the use of salt, as a manure, is a subject on which the public opinion is much divided: its advocates, reasoning from the striking effects of salt-water on the marshes, which are occasionally irrigated by the sea at spring-tides, conclude that the fertilizing virtue of such irrigation is owing to its saline quality, without taking into consideration the quantity of animal and vegetable matter, which sea-water (particularly near the coast, and where rivers disembogue themselves) must necessarily hold in solution. But that those who maintain a contrary opinion, considering salt merely as an antiseptic, satisfy themselves that it is impossible that any thing can be friendly to vegetation which retards putrefaction, a process indispensable in substances that are to be the food of plants. To get over this difficulty, it has been conjectured, nay, there have not been wanting those (and of great name too) who have even attempted to prove, that salt in small quantities accelerates, as in large quantities it is known to resist, putrefaction; a doctrine to which, however, he shall not willingly yield his assent, till he can be persuaded that effects are not, in all cases, proportionate to their causes. The operation of every cause is, and must, he contends, be uniform; and when, to appearance, it is not so, some other cause obtrudes itself, too subtile for our observation, which operating at the same time with the primary cause, joins in giving a result, which not being able to account for, we consider as anomalous. He thinks, that theorists should be at variance with each other is not to be wondered at; for having the wide field of imagination and conjecture before them to expatiate in, it is reasonable to conclude, indeed it is unavoidable, that some of them must lose their way. But what shall we say to the disagreement and inconsistency which prevail on the subject amongst practical farmers? Nothing, indeed, can be more contradictory than the different reports that have been made on the effects of salt, as a manure, by those who have even brought it to the test of actual experiment. As there is no reason to question the veracity of the reporters, we must look for the grounds of their disagreement in some predominating circumstance or other, which at the time escaped their observation. Indeed, the success or failure of an agricultural experiment depends so frequently on causes, which can neither be controlled nor foreseen, and so foreign from those which were expected to operate, that it is not to be wondered at if the repetition of the very same experiment gives oftentimes a different result to the inquirer. But as it is not the business of this paper to support a theory, but to detail what has been practised; not to contend for an opinion, but to state facts; the few observations which may be hazarded, will be such only as are required merely in explanation of occurrences, as they arise. He shall endeavour to give, therefore, as simple a relation as possible of the experiments he has tried, to ascertain the advantages or disadvantages which may attend the use of salt as a manure, and also when mixed with the food of animals, and employed in that way.

In regard to the first of these objects, it is stated that the soil on which his trials were made was a ferruginous sand, brought to a due texture and consistence by a liberal covering of pond-mud. Of this soil, in its improved state, he means by the accession of pond-mud, (for having been used merely as a nursery for raising forest-trees previous to these experiments, the nursery-man had not thought it necessary to make use of any other manure), the subsequent analysis is given:

	Grains.
About 400 grains gave of siliceous sand, of different degrees of fineness, about - - -	280
Of finely divided matter, which appeared in the form of clay - - - - - - -	104
Loss in water - - - - - - - -	16
	400

The 104 grains of finely divided matter contained of carbonate of lime - - - - -	18
Of oxyd of iron - - - - - - -	
Loss by incineration (most probably from vegetable decomposing matter) - - - -	17

The remainder principally silex and alumine.

And it is added, that there were no indications of either gypsum or phosphate of lime. And that from this analysis it will appear, he thinks, that these experiments could not, perhaps, have been tried on a soil better adapted to give impartial results; for of its component parts, there is no ingredient (the oxyd of iron possibly excepted) of sufficient activity to augment or restrain the peculiar energies of the substances employed in the business.

It is ſtated farther, that on the 14th of April 1804, a certain portion of this ſoil was laid out in beds, one yard wide, and forty long. Of theſe, twenty-five were manured (the firſt excepted) in the following manner:

N° 1. No manure.
2. Salt, a quarter of a peck.
3. Lime, one buſhel.
4. Soot, one peck.
5. Wood-aſhes, two pecks.
6. Saw-duſt, three buſhels.
7. Malt-duſt, two pecks.
8. Peat, three buſhels.
9. Decayed leaves, three buſhels.
10. Freſh dung, three buſhels.
11. Chandlers' graves, nine pounds.
12. Salt, lime.
13. Salt, lime, ſulphuric acid.
14. Salt, lime, peat.
15. Salt, lime, dung.
16. Salt, lime, gypſum, peat.
17. Salt, ſoot.
18. Salt, wood-aſhes.
19. Salt, ſaw-duſt.
20. Salt, malt-duſt.
21. Salt, peat.
22. Salt, peat, bone duſt.
23. Salt, decayed leaves.
24. Salt, peat-aſhes.
25. Salt, chandlers' graves.

N.B. The quantities of each ingredient the ſame as when uſed ſingly.

And that on the ſame day the whole was planted with potatoes, a ſingle row in each bed; and that the general experiment might be conducted with all poſſible accuracy, each bed received the ſame number of ſets. That on the 14th of May, (a few days after the plants appeared above ground,) the whole was carefully examined, and the comparative excellence of each row (as far, at leaſt, as could be judged of by appearances) was as carefully regiſtered. The beſt row was decidedly N° 7, malt-duſt; after which they followed in order, as below.

N° 11. Chandlers' graves.
16. Salt, lime, gypſum, peat.
25. Salt, graves.
20. Salt, malt-duſt.
9. Decayed leaves.
4. Soot.
2. Salt.
1. No manure.
5. Wood-aſhes.
8. Peat.
13. Salt, lime, ſulphuric acid.
14. Salt, lime, peat.
17. Salt, ſoot.
18. Salt, wood-aſhes.
21. Salt, peat.
22. Salt, peat, bone-duſt.
23. Salt, decayed leaves.
3. Lime.
6. Saw-duſt.
10. Freſh dung.
12. Salt, lime.
15. Salt, lime, dung.
24. Salt, peat-aſhes.
19. Salt, ſaw-duſt.

Further, that on the 28th of May, fourteen days afterwards, the apparent vigour of the plants was in the following order:

N° 7. Malt-duſt.
11. Chandlers' graves.
4. Soot.
8. Peat.
16. Salt, lime, gypſum, peat.
17. Salt, ſoot.
20. Salt, malt-duſt.
21. Salt, peat.
23. Salt, decayed leaves.
25. Salt, graves.
1. No manure.
2. Salt.
5. Wood-aſhes.
9. Decayed leaves.
13. Salt, lime, ſulphuric acid.
14. Salt, lime, peat.
18. Salt, wood-aſhes.
24. Salt, peat-aſhes.
10. Freſh dung.
3. Lime.
22. Salt, peat, bone-duſt.
19. Salt, ſaw-duſt.
15. Salt, lime, dung.
12. Salt, lime.
6. Saw-duſt.

And that on the 21ſt of September, the potatoes were taken up, when the produce of each row was in ſucceſſion, as follows:

N° 17.	Salt and ſoot	produced	240
11.	Chandlers' graves		220
18.	Salt, wood-aſhes		217
16.	Salt, gypſum, peat, lime		201
15.	Salt, lime, dung		199
2.	Salt		198
25.	Salt, graves		195
4.	Soot		192
10.	Freſh dung		192
20.	Salt, malt-duſt		189
5.	Wood-aſhes		187
23.	Salt, decayed leaves		187
24.	Salt, peat-aſhes		185
7.	Malt-duſt		184
14.	Salt, lime, peat		183
19.	Salt, ſaw-duſt		180
22.	Salt, peat, bone-duſt		178
9.	Decayed leaves		175
13.	Salt, lime, ſulphuric acid		175
21.	Salt, peat		171
12.	Salt, lime		167
8.	Peat		159
1.	No manure		157
6.	Saw-duſt		155
3.	Lime		150

It is here ſtated as ſingular, that of ten different manures, moſt of which are of known and acknowledged efficacy, ſalt, a manure hitherto of ambiguous character, is ſuperior to them all, one only excepted! and that when uſed in combination with other ſubſtances, it is only unſucceſsfully applied in union with that one, namely, chandlers' graves, no other manure ſeemingly being injured by it. Poſſibly its deteriorating effects on chandlers' graves may be owing to its antiſeptic property, which reſiſts the putrefactive proceſs, by which animal ſubſtances undergo the changes neceſſary to qualify them to become the food of plants. This, however, he cannot, from any appearance in the ſoil, when the plants were taken up, aſſert to have been the caſe. And the extraordinary effects of ſalt, when combined with

foot, are, he obferves, ftrikingly fingular. There is no reafon to fuppofe thefe effects were produced by any known chemical agency of foot or falt on each other. Were he to guefs at the producing caufe, he fhould conjecture it to be that property of faline fubftances, by which they attract moifture from the atmofphere: for he obferved thofe beds, where falt had been ufed, were vifibly and palpably moifter than the reft, even for weeks after the falt had been applied; and this appearance continued till rain fell, when, of courfe, the diftinction ceafed. This property of attracting moifture had greater influence, poffibly, on the foot than on any of the other manures; as foot, from its acrid and dry nature, may, he thinks, be fuppofed to require a greater proportion of water to dilute it than thofe fubftances which contain water already. It may be proper to obferve, that on thofe beds where falt had been ufed, the plants were obvioufly of a paler green than on the reft, though not lefs luxuriant; a circumftance which he thought worth noticing, and which he confidered, though erroneoufly, (as appeared by the event,) to indicate a want of vigour, which would be felt in the crop. It was obfervable alfo, that where falt was applied, whether by itfelf or in combination, the roots were free from that fcabbinefs which oftentimes infects potatoes, and from which none of the other beds (and there were in the field nearly forty more than what made part of thefe experiments) were altogether exempt. This circumftance deferves the notice of the practical farmer. And it is further noticed by the fame writer, that two fets of experiments, and with the fame proportions of manures, were tried with turnips and buck-wheat, on a foil the pooreft he could meet with, which produced only a dwarf heath and lichen, and which he had pared off. The poverty of this foil will appear by the following analyfis:

	Grains.
400 grains gave of filiceous fand - - -	320
Of finely divided matter, which appeared as brown mould - - - - - - - -	68
Lofs in water - - - - - - - -	12
	400

And that the finely divided matter loft by incineration nearly half its weight, which fhews it contained a great deal of vegetable matter. The refiduum, principally a mixture of aluminous and filiceous earths, coloured red by oxyd of iron, and containing very little calcareous matter. There were no indications of either gypfum or phofphate of lime in it.

On July 6, 1804, the pieces fet apart for each fet of experiments were refpectively fown with turnips and buck-wheat. On the 26th, Nos. 1, 2, 4, 5, 6, 7, 19, 20, 21, 22, 24, 25, fhewed little or no marks of vegetation. Thofe that remained were merely in the feed leaf. And that on the 16th of Auguft, four only were alive and in rough leaf, namely,

No. 12. Salt and lime.
13. Salt, lime, and fulphuric acid.
14. Salt, lime, peat.
16. Salt, lime, gypfum, peat.

And it is added, that thefe four maintained a fickly exiftence till the middle of September, fhortly after which they all difappeared. And it is remarked, that the appearances of the turnips and buck-wheat were fo nearly uniform, that he has not thought it neceffary to notice the trifling variations between them, which could not have been done without entering into a minute detail, equally tedious and uninterefting to the inquirer. It is, however, fuggefted, that though no decifive conclufion can be drawn from thefe two fets of experiments refpecting the advantages or difadvantages of falt as a manure, on fuch a foil as he has defcribed, becaufe other manures of acknowledged efficacy fhared the fame fate with the falt, yet this inference may, he thinks, be drawn from them, (and that not an unimportant one,) namely, that a due texture and confiftence in the foil is as neceffary to the exiftence and health of vegetables as the pabulum they are fuftained by; and this appears evidently by the fuperiority (fuch as it was) of thofe plants where the manure contributed, in any degree, to improve that texture and confiftence. This is, he contends, fully fhewn by an adjoining field, which within thefe few years was in a great part in a ftate of uncultivated nature, equally barren as the fpot he has been fpeaking of; it is, however, now brought into cultivation, and into a decent ftate of fertility, chiefly from its texture having been improved by a thick coating of marley clay.

But thefe facts and experiments fhew the effects of falt in a more favourable light as a manure, than it has been hitherto generally confidered in; and the intelligent writer fuggefts, that if its beneficial properties were more perfectly demonftrated, the attention of the legiflature would devife fome meafure, without prejudice to the revenue, by which it might be employed for the purpofes of hufbandry.

There are, in a communication from Davies Giddy, efq. prefident of the Penzance Agricultural Society, inferted in the twenty-feventh volume of the Annals of Agriculture, fome interefting experiments on the ufe of fea-falt in the culture of turnips detailed. They are enabled to make ufe of this fubftance as a manure, from the extenfive pilchard-fifhery eftablifhed on the coaft. Salt is frequently imported for curing fifh at 9*d.* or 9½*d.* the bufhel of eighty-four pounds, and what remains after it has been once, or fometimes twice ufed in preferving the pilchards, is ufually fold at about the fame price to the neighbouring farms. Though fome animal oil is united to the falt, that which has been the leaft ufed is univerfally preferred, and found the moft effectual. It is fuppofed perhaps difficult to determine whether the whole efficacy of the falt in producing plentiful, and, as it would feem, certain crops of turnips, can be imputed to its virtues as a manure, or whether part of the effect may not be owing to the deftruction of flugs.

The Report is thus ftated by the Rev. John Allen, and Mr. Sickler, two members of the fociety: at Michaelmas 1790, Mr. Sickler entered on an eftate fo much impoverifhed by the former tenant, as fcarcely to return the feed.

In the fpring of 1791, Mr. Sickler prepared two acres for turnips, which had borne feven crops of oats in fucceffion. The laft crop did not produce nine bufhels on an acre.

In the firft week of April the earth from the ditches was carried into the field, and laid in four piles; each received three cart-loads of fea-fhell fand, and five bufhels of falt. The earth from another ditch, chiefly confifting of the decayed foil, which had been taken off the ground in former tillage, was placed in three more piles, and each of thefe received alfo three cart-loads of fand, but no falt, on account of the apparent richnefs of the earth. Half the field was manured with the four firft piles, but the three laft not being fufficient for the other half, what remained was fown with falt, at the rate of ten bufhels to an acre.

The part of the field where falt had been ufed, either mixed with earth, or alone, produced about half a crop of turnips, but the crop totally failed where there was no falt,

In the fpring following, white oats were fown, and produced a crop of forty-five bufhels to an acre.

In 1792, three acres, which in 1791 had borne a crop of wheat, not exceeding twelve bufhels on an acre, were ploughed before Chriftmas, and brought into fine tilth by Midfummer following. On each acre were fown twenty bufhels of falt, excepting that two ridges towards the middle of the field were purpofely left without any manure; on thefe two ridges the turnips totally failed, but the remainder of the field produced a plentiful crop.

In 1793, four acres of land, completely worn out by fucceffive tillage, were ploughed before Chriftmas; three acres were fown with falt, at the rate of twenty-five bufhels, and the remaining acre with eighteen bufhels, without any other manure: the crop was in general a good one, but vifibly beft where the greateft quantity of falt had been ufed. Crops of turnips have been raifed with equal fuccefs by the ufe of falt, fince that time, and in the fevere winter of 1794—5, it was obferved that thefe turnips were much lefs injured by the froft than others fimilarly treated, and cultivated in the common way. When falt is ufed in the quantity of twenty or twenty-five bufhels to an acre, the turnips fhould not be fown till at leaft three weeks after the falt. Clover fown with barley after turnips raifed by the ufe of falt, has never failed to produce an abundant crop of hay the year following. It is fuggefted in the Report, that if the obfervation can be depended on of turnips being lefs injured by froft when they are manured with falt, than when they are cultivated in the ufual manner, it muft indicate an extraordinary degree of health and vigour in the plant; but a fingle obfervation is obvioufly infufficient to eftablifh fuch a fact. It is alfo fuggefted by Mr. Jay, after obferving that the nature of the foil, and perhaps the feafon fhould be regarded, as that may poffibly account for certain proportions of falt fucceeding much better in fome inftances than in others;—that a gentleman in New England, in America, has publifhed fome facts, from which it appears that the fubject merits attention.

It is noticed, that in June 1786, he falted one bed of his onions, one bed of his carrots, and one bed of his early turnips: laying the falt under the furface, in the centre of the intervals between the rows, at fome diftance from the roots, that the falt might have time to be diffolved and altered before the fibrous roots fhould reach it. The carrots of the falted bed evidently grew much larger and better than the reft, but he could not perceive that the falt was at all beneficial to the onions or to the turnips. And further, that according to Mr. Ford's experiments in falting flax ground, falt feems to be highly beneficial to that crop. He fpreads the falt at the time of fowing the feed, and thinks that the quantity fhould be *double* to that of the feed: from three acres of flax falted he had fifty bufhels of feed, and an excellent crop of flax. Mr. Elliot tells us of *five* bufhels of falt being applied to one acre of flax, which is a much larger proportion, and that it had an extraordinary effect: and alfo of a crop of wheat increafed by falt.

But the trials of Mr. Fenna in Chefhire, with this fubftance as a manure in various modes of application, do not however appear to have been fo fuccefsful, though they feem to have been made with much care and attention.

On Fallow.—July 1, 1797. Experiments on a fallow for wheat being once ploughed, and that before Chriftmas laft, full of grafs and weeds, owing to the continual wet weather.

		A.	R.	P.		lbs.		Bufh.	lbs.	
3 butts		0	2	4	fown with	$85\frac{1}{2}$	of falt, that is,	2	50	*per* acre
2 ditto adjoining		0	1	26	unfown.					
3 next ditto	-	0	2	35	fown with	89	ditto,	2	11	
2 — ditto	-	0	1	35	unfown.					
3 — ditto	-	0	2	5	fown with	130	ditto,	4	20	
2 — ditto	-	0	1	13	unfown.					
3 — ditto	-	0	3	74	fown with	193	ditto,	7	25	
3 — ditto	-	0	1	7	unfown.					
3 — ditto	-	0	1	34	fown with	175	ditto,	6	42	
3 — ditto	-	0	1	17	unfown.					
3 — ditto	-	0	1	13	fown with	195	ditto,	10	25	

Obfervations.—July 12, 1797. Some few of the weeds have perifhed, but no other evident alteration, compared with thofe unfown, and none at all upon thofe fown with fmall quantities. Ploughed under between the 7th and 14th of July, the weather being rather drying, but ftill fhowery.

July 12. Salt fown on the fame fallow being twice ploughed, the weather drying.

	A.	R.	P.		lbs.		Bufh.	lbs.	
1 butt	0	0	22	fown with	$76\frac{1}{2}$	of falt, that is,	9	49	*per* acre
1 ditto	0	0	18	fown with	$78\frac{3}{4}$	ditto,	12	21	
1 ditto	0	0	33	fown with	109	ditto,	9	34	

Additional Obfervations.—It is ftated that fome few fnails perifhed by the application the day following. No other perceptible alteration has yet taken place.—Auguft 28; has been harrowed and ploughed a third time. It is fuggefted, that a man fowing from a feed-hopper, common ftride and full hand, twice over the fame ground, will fow from ten to twelve bufhels *per* acre.

Oct. 1, 1797. Sowed another butt in the fame fallow with falt, immediately before its being fown with wheat, and ploughed in therewith, being after the rate of ten bufhels *per* acre. No vifible advantage has been feen in any of the above, through the winter, or at fpring, nor any perceptible advantage as the crop advanced to maturity; neither could the reapers, nor any other viewers, diftinguifh the leaft appearance in favour of falt compared with the butts unfalted.

On Paftures.—June 30. Sowed 0 *a.* 0 *r.* 17 *p.* of pafture with 4 lbs. 4 oz. of falt (being rye-grafs and clover of the fecond year's growth, foil pretty good upon marle).

Sowed 0 *a.* 0 *r.* 13 *p.* with falt (2 lbs. 12 oz.) being paf-

ture of feveral years' growth, full of wild or natural clover; foil deeper and warmer than the former.

July 1. Sowed 0 *a.* 0 *r.* 35 *p.* with $17\frac{1}{4}$lbs. of falt, being pafture of the third year's growth; foil open, upon fand productive of fern.

December 1, 1797. Sowed part of a butt with falt, after the rate of 15 bufhels *per* acre.

December 1. Sowed 8 lbs. of falt on part of a rough meadow, having nearly its whole fummer's growth of four grafs, which the cattle would not eat, and has been ufually burnt off at fpring.

Obfervations.—July 12. No evident alteration compared with the adjoining land. Auguft 28, continues unaltered.

In fpring 1798, not forwarder, nor any wife preferable to the adjoining butts of ground which were not falted.

Some thiftles and fome little of the fern damaged, but not deftroyed. The rough or four grafs being in a withered or dead ftate, though fown with fine falt when dewy, was not affected thereby, neither did the cattle prefer it to the other not falted.

On Mowing.—July 17. Sowed $39\frac{1}{2}$lbs. of falt upon 0 *a.* 0 *r.* 14 *p.* a cold peaty meadow (herbage indifferent, intermixed with rufhes) immediately after the hay being carried off, the weather dry. N.B. Eight bufhels *per* acre.

Obfervations.—July 25. The weather broke, and much rain has fince followed, but no vifible alteration has yet taken place.—Auguft 27. This is not a fufficient quantity to deftroy the herbage, nor has any advantage yet appeared. Neither has the fpring nor the crop of hay-grafs fhewn any thing preferable to the unfalted parts adjoining.

On Hay.—Auguft 13. Scattered 3lbs. of falt in a ton of new hay at the time of houfing, being a little weathered. This hay appeared lefs mouldy, and on that account was better than the fame unfalted, but would not compare with the like hay which had not been weathered, and not falted.

On Weeds and Brambles.—June 30, 1797. Applied 4 oz. of falt to 4 oz. of weed-wifs (in Gerrard's Hiftory of Plants called *geniftella tinctoris*, dyer's weed, or baftard broom), tufts, or roots, occupying a fpace twelve inches in diameter, in equal quantities. The ground being wet with almoft continual rains for a month paft.

Obfervations.—July 1. Began to droop.—July 12. Dead. —Auguft 28. Three of them are rotted away, and their place growing over with grafs: the other has its woody fubftance yet ftanding, though dead. Thefe fprang up from the old roots this fpring, 1798, and have continued in the fame flourifhing ftate as they were before the application of falt, July 1797.

July 1, 1797. Applied 7lbs. of falt to a number of the hard kind of rufh-tufts, or bogs in the pafture.

Obfervations.—The cows found it the next day, and collected as much as they could, together with every blade of grafs growing amongft the rufhes. Some few of the rufhes were bit off in confequence of their fearch; the remainder did not die; nor fuffer any apparent damage from the application, Auguft 28. It has been found, by fubfequent trials, that the cows take this, in the act of licking the grains of falt with their tongues, and that where the grains have been diffolved, the herbage is not preferable, on account of its having been falted.

July 12, 1797. Ten pounds, ufed upon a poor furze, or gorfey bank, chiefly clay foil, being then almoft totally overgrown about twelve or fixteen inches high; in quantity about eighty fquare yards; the weather dry.

Obfervations.—The cows found this, and ftole all that they could get at, together with any decent herbage with which it was intermixed. Some little of the gorfe has perifhed, but it is far from being deftroyed.

Auguft 28. The whole recovered at the return of fpring (1798), and fo continues.

July 12, 1797. Ufed feveral pounds of falt upon a number of weed-wifs, or baftard-broom, tufts, or roots (the four falted the 30th ult. being dead); the weather dry.

Obfervations.—July 27. They are in part deftroyed. The cows found this, and collected as much as they poffibly could, without eating the weed, which is very bitter. It is alfo obferved, that thefe retained their verdure much longer than thofe falted in wet weather.—Auguft 28, and not yet deftroyed, but much hurt. Thefe, like the former, recovered in the fpring of 1798, and fo continue (July 1798).

July 12, 1797. Ufed 10lbs. of falt upon more rufh-tufts or roots in the pafture, a greater quantity to each.

Obfervations.—The cows found it in a fhort time, and felected every grafs from amongft the rufhes, together with as much of the falt as they could. Some of the rufhes fuffered in the purfuit, being bitten off and thinned.—Auguft 28. The rufh-roots are too deep to be deftroyed. Grafs, and other herbage near, has fuffered. Thefe, in 1798, are not to be diftinguifhed from the others not falted.

Auguft 25, 1797. Ufed 6lbs. upon 15 fquare yards of ground almoft totally overgrown with hen-gorfe (in Gerrard's Hiftory of Plants called *ononis five refta bovis*, cammock, or reft-harrow), a pernicious woody fhrub infefting clay foils, being then in full flower, and beginning to fet its feed-pods; the weather fhowery.—Auguft 28. The leaves and flowers are dying. The branches died foon after; but the roots fent out frefh ones at the return of fpring, which ftill continue. This being upwards of thirty bufhels to the acre, deftroyed the intermixed grafs, which became brown and lifelefs till the approach of winter, when it began to recover, and the whole was covered by the fpring; but no better herbage than the adjoining; nor has it any time fince been preferable, July 1798. This quantity was not fufficient to leave the ground quite bare. Though the herbage was killed, it never totally difappeared. If a leffer quantity would have done fo, it might have been ferviceable for deftroying the fward previous to the making of a lay fallow. Salt has been ufed from fifteen to twenty bufhels *per* acre, upon fmall patches of nettles in deep-foiled pafture, which were fretted awhile; but afterwards recovered, without any vifible alteration in their growth.

It is further obferved, that it has likewife been tried (1798) in various proportions, and at different times, upon a turnip fallow, without any good effect. It was fown upon a weedy part of the turnips, to the amount of ten bufhels *per* acre; after they were up in three or four rough leaves, thefe were fretted; but the greateft part of both weeds and turnips recovered with little variation from the other (rather worfe if either). How falt would act upon worms, or what is called the fly, is not known, as the crops were not plagued with them this laft year; probably it would have a good effect; for falt-water was tried upon worms on a goofeberry-bufh, without fretting the tree much, the worms foon after died; but, as this was only one inftance, perhaps a change of weather, or fome other caufe, might occafion their death. This experiment is intended to be repeated both on turnips and on goofeberries in future. And it is added by the writer, that *with cut ftraw* falt has been tried, mixed and immediately given, put together and left to ferment, and fprinkled with falt and water; in every cafe it is refufed by the cattle.

And that *in manure*, salt mixed with dung, in various proportions, and in different sorts, is not discoverable from the same sort, set on without salt.

On the 3d of January, 1798, 67lbs. of salt were mixed in two square yards of tough peaty parings, cut from the sides and bottoms of an open peaty drain, and made in a heap of that size. The remainder of the same parings were made in another heap, and mixed up with a quantity of horse-dung of proportionate value, allowing the salt to be 2*s. per* square yard. Both sorts were examined by sir Robert S. Cotton, the beginning of August last, at which time the admixture with salt remained in a dead tough state, without any rotten or saponaceous particles in it; the blades of grass in the middle of the heap, though dead, had not lost their colour. No weed or any vegetable had grown upon this heap; but the other mixed with dung was covered with weeds, and on opening was found much reduced and pulverized; and after one good turning and mixing, was set upon the ground in good condition, in November last; the other has since been twice turned, and remains in the heap unrotted at this day, March 1799. From hence it may be concluded, that salt acts not as a septic on vegetable substances, but, on the contrary, preserves them in a dead state, and acts as a preventative to putrefaction: this is perhaps more fully proved by the common method of preserving kidney or French beans, when ripe enough for the table, which are kept the year round for culinary purposes in pots, between layers of dry salt. The writer also states, that from the foregoing experiments it may be concluded, that salt may be of service to agriculture in the preparation of fallows, in rainy seasons unfavourable to the plough; but in this case great quantities must be used to have the desired effect; perhaps less than fifty bushels to each acre would be insufficient: this quantity would not destroy vegetation for more than two months, as appears from the first experiment with weed-wifs, where something more than that quantity was used: this quantity might destroy the weeds, but would not reduce it, if in a tough or soddy state, as appears from the last experiment in manures, where the quantity used is equal to 240 bushels *per* acre, allowing it to penetrate the surface of the fallow, in an equal degree, only three inches deep. And that perhaps it would be more beneficially used in small quantities with hay at the time of housing or stacking, which, if weathered or damp, might prevent it in some degree from becoming mouldy, and, if green and in large quantities, might act as a preventative to overheating and firing. But that as an assistant, or stimulus, to the vegetable system, it appears, through all the foregoing experiments, to be quite destitute of every good property, and unworthy of notice as a manure in any kind of process. And that such is the opinion of several of the neighbouring farmers who have viewed the different applications, and who have, without exception, concurred in the report which is here made.

It is, however, advised by Dr. Darwin, that, because salt, when made use of as a manure, has a tendency to induce disease by its excessive stimulant power, it should be employed a little before the time that the plant would acquire that part of its growth which is wanted. But though this may be done in the garden, it cannot be well extended to the field.

Notwithstanding these results, other trials made in the same district, as well as in others, lead to different conclusions. It was found, in one attempt, on four rushy land after draining, by spreading on one part in the autumn refuse salt, at the rate of eight bushels to the acre, and on another part sixteen bushels to the same extent; that in a short time the vegetation wholly disappeared, not a blade of grass being to be seen during the early part of the succeeding spring, but towards the end of May a most flourishing crop of rich grass appeared on the eight-bushel portion. After the middle of summer, the other portion too produced a crop still stronger; the cattle were remarkably fond of it, and during the whole ensuing winter, and to this time, which is ten or twelve years since, the land has retained, and still exhibits, a superior verdure to the neighbouring closes. In another trial, in a meadow, the after-grass of which was of so coarse and rank a nature as to be refused by the cattle, on salt being laid upon one part of it, they have ever since preferred the grass growing on that part to every other, and eaten up every blade. It has also, it is said, good effects in mixture or compost with other coarse manures, producing strong crops of barley and hay-grass. On some foul salt being laid upon a court pavement to destroy the growth of grassy matters, though in the first summer afterwards not any thing appeared, in that which succeeded it the vegetation was greatly more abundant than before the salt was used. It has equally beneficial effects, it is said, on fallow land: by using it at the time of breaking up the land, its strong saline properties destroy vegetation and all noxious insects; and mixing intimately with the mould before the grain is put in, it strongly supports and insures the best crops.

In other experiments, when employed in compost with earth, in comparison with lime in mixture with the same earth, on such being laid on different parts of the same field, that part which had the lime compost vegetated strongly, but bore no sort of comparison to the health and vigour of growth in the crop of that which had the salt compost. The latter is still capable of being marked out and traced by the stronger growth of grass or it, notwithstanding the time that has since elapsed.

In using it pretty thickly, without being mixed with the earth on a portion of land, the expected benefit was not only not received, but the vegetation was destroyed, and the ground left almost bare, which was attributed to the manner of application, as being unfavourable and improper.

The water of salt-brine springs, where they break out and spread upon the surface, is however stated to have the effect of destroying all vegetation for the space of several yards about them in particular cases: while in the natural application on the marsh-lands, it appears to produce effects somewhat of a contrary kind; as where the salt-water of the sea overflows them, the vegetation is by no means deficient in vigour.

The difference in the effect of salt, applied as a manure, is attempted to be accounted for by the writer of the corrected Cheshire Agricultural Report, by referring it principally to two causes; namely, a variation in the manner and degree of its application, and a difference in the nature of the soils or lands on which the trials with it have been made. The first of these causes must, it is thought, have a great influence on its action upon vegetable matter as that of a stimulus, and consequently that its effects must be greatly varied by the proportion applied. When employed in a large quantity, it may, like every other excessive stimulus, tend to disorganize and destroy the vegetable substances with which it comes into contact. When used in a smaller proportion, or in mixture as a compost, it may be regarded, by the moderate stimulus it gives to the action of the vessels in the plants, as a promoter of vegetation, and, of course, as a valuable manure. The writer is aware that this is not perfectly conformable to the opinion of some, but he thinks it the most consistent with the general

analogy of nature, as well as with particular experiments on the fubject. In fallows it would feem that it might be beneficial in large quantity, by the deftruction of all ufelefs vegetable and animal matter; which, at the fame time, would be fo much reduced and fpent by the time the feed was put into the ground, as to fit it for producing that degree of ftimulus, which is moft adapted to healthy vegetation. The differences of the nature of foils muft obvioufly produce great variety in the refults of the different trials which are made to afcertain its particular nature.

Sir Humphrey Davy, in his "Agricultural Chemiftry," feems, however, to think it probable that common falt acts as a manure, by entering into the compofitions of the plants fomewhat in the fame manner as gypfum, phofphate of lime, and alkalies. See thefe heads, SALINE *Manure*, and SULPHATE *of Lime*.

And that as it has been ftated, from good authority, that falt, in fmall quantities, promotes the decompofition of animal and vegetable matter; that circumftance may alfo render it ufeful in certain foils and kinds of land. Common falt is likewife offenfive to infects. In fhort, that in fmall quantities, it is fometimes beneficial in the intention of manure, he thinks, is now fully proved; and that it is probable that its efficacy may depend upon many combined caufes. The reafonings againft the ufe of it urged by fome, on the grounds, that when applied in large proportions it either does no good, or renders the land fterile, are confidered as very unfair and improper; as the circumftance that falt in large proportions rendered land barren, was well known long before any records of agricultural fcience exifted, from the fcite of a city having been ftated in the Scriptures to have been fown with falt, that the ground might for ever remain unproductive. And that though Virgil reprobated a falt foil; and Pliny, who advifed it for cattle, affirmed, that when difperfed over land it caufed it to be barren, thefe are not by any means reafons againft the proper ufe of it. The refufe falt of the fifheries of Cornwall have been feen above, and long known to be an excellent manure, but they contain, as well as the falt, fome oil and exuviæ derived from the animals.

Upon the whole, it is thought not unlikely, that the fame caufes may influence the effects of falt, as thofe which have a power in modifying the action of fulphate of lime, as already noticed.

Moft lands in this country, efpecially thofe near the fea, it is fuppofed, probably contain a fufficient quantity of falt already for all the purpofes of vegetation; and that in fuch cafes the fupply of it to the foil will not only be ufelefs, but may be prejudicial. It is noticed, that in great ftorms the fpray of the fea has been carried more than fifty miles from the fhore; fo that from this fource falt muft often be fupplied to the foil. Salt has alfo been found in all the fand-ftone rocks that the above writer has examined, and it muft, it is faid, exift in the foil, or the mould that is derived and formed from them. It is a conftituent, likewife, of almoft every kind of animal and vegetable manure, therefore it muft prevail very confiderably.

Salt has been employed upon fallows, in fome cafes, with good effects, and the refufe of it would probably be found beneficial in many circumftances of land, if it was allowed to be taken from works of this nature, free of duty, and which would not unfrequently be a material convenience to the proprietors.

Many additional facts, experiments, and obfervations will, however, probably be neceffary, in order fully to afcertain the nature and utility of falt as a manure.

Ufe of Salt for domeftic Animals.—And it is conceived by Dr. Anderfon, that there is no fubftance yet known which is fo much relifhed by the whole order of graminivorous animals, as common falt. The wild creatures of the defart are fo fond of it, that wherever they difcover a bank of earth impregnated with a fmall proportion of falt, they come to it ever after regularly to lick the faline earth, as they would to a pool of water to drink, were there none other near; fo that when a hunter in America difcovers fuch a *lick*, as fuch places are there called, he reckons himfelf fure of obtaining plenty of game, by lying in wait near it, and fhooting them as they approach, until the whole beafts that have difcovered it are killed. And it is alfo admitted by all thofe who have tried the experiment, that falt, given along with the food of domeftic animals, (except fowls, to which falt is a certain poifon,) tends very much to promote their health and accelerate their feeding; and although fome perfons, who have been at a lofs to account for the manner in which this ftimulant could act as a nutritious fubftance have affected to difregard this fact, yet no one has been able to bring the flighteft fhow of evidence, to invalidate the ftrong proofs that have been adduced in fupport of it, though, unfortunately for this country, few experiments of this kind have been tried in it. In fact, we have no reafon to fuppofe that falt acts in the fmalleft degree as a nutritious fubftance, or of *itfelf* tends to fatten any animal; but that merely by acting as a condiment, it whets the appetite, and gives the creature to which it is probably adminiftered a ftrong relifh for its proper food, fo as to induce it to eat in a *given* time a greater quantity than it would have done, and thus greatly to augment, as has been above explained, its feeding quality beyond what it otherwife could have had. In this way it is not, perhaps, an extravagant pofition to fay, that by a proper ufe of common falt, the fame quantity of forage might, on many occafions, be made to go twice as far as it could have gone in feeding animals, had the falt been withheld from them. If fo, and let thofe who are inclined to withhold their affent to this pofition, prove, by a fet of experiments fairly conducted, that it is erroneous; till then, the unvarying teftimony of the few who have tried it, confirming the pofition, ought to be relied on. If fo, then we have here laid open to our view an eafy mode of augmenting the produce of our fields to an amazing extent; for, if the fame quantity of forage can be made to go, not twice as far, but one-twentieth part only farther than it now does, it would be the fame thing as adding one-twentieth part to the aggregate produce of meat for beafts, throughout the whole kingdom.

It has alfo been fuggefted by a writer in the firft volume of the Memoirs of the Royal Academy of Sciences at Paris, which is inferted in the 24th volume of Young's Annals, that vaft advantage may be derived from the ufe of falt, in promoting improvements in land as well as in increafing the number of cattle. The farmer, it is obferved, who has more than an ordinary ftock of working cattle, reaps a double advantage, the one by having his work done in feafon, the other by enriching a greater proportion of his land by means of their additional manure. The only difficulty is how to maintain an increafed number without increafing the expence; this, he afferts, may be done by the ufe of falt, and advances the three following propofitions.

1. That falt, given with the food of cattle, augments the nourifhment of that food.

2. That in proportion to the quantity of falt eaten by cattle, the effects of that augmentation will be perceivable.

3. That no ill confequence will follow from an excefs of falt eaten by cattle, even though it fhould be given them without ftint. And thefe propofitions he endeavours to

support by unquestionable facts. In the jurisdiction of Arle, in the county of Provence, there is a district called the Craw, extending in length about six leagues, and in breadth about three, the whole surface of which is covered with small rough stones, and not a tree or bush to be seen in the whole district, except here and there upon the borders; yet on this spot, so seemingly sterile, by the free use of salt, more numerous flocks of sheep are bred and reared than upon any other common, of equal extent, throughout the whole kingdom. And what is no less remarkable, the sheep are healthier, hardier, and endure the severity of winter with less loss, though they have fewer sheep-cots for covering them, than those bred and fed on more copious pastures, and besides they have not the advantage of more convenient shelter. Add to this, that the wool of the flocks bred and brought up in the Craw is not only the finest in the whole country, but bears the highest price of any in France. From hence he concludes that it is to the unlimited use of salt that these surprising effects are to be ascribed, for it frequently happens that the Craw is so burnt up in the summer that the poor animals are forced to turn up the very stones to come at the few blades of grass that grow round them, and yet none perish for want of food; let every excellence therefore, that can reasonably be supposed inherent in the herbage, be allowed to it, yet the quantity of it is so small, that without the abundant use of salt, a fourth part of the sheep kept in the Craw could not subsist in it.

But as a still farther demonstration that this astonishing effect is solely to be attributed to salt, we have, says the writer, in Languedoc, on the borders of the Rhone, a spot of the same kind of stony land, in every respect similar to that of the Craw, yet for want of the free use of salt, that in Languedoc does not maintain the tenth part of the number of sheep that are brought up in the Craw, though in other respects it is no ways inferior, their wines and other fruits produced in the borders of both being in their goodness and other essential qualities, equal.

Having thus proved his first proposition incontrovertibly, he proceeds to prove the second, and to recommend an easy experiment, which it is in every farmer's power to make, and that is, to give one half of his cattle salt, and the other half none. By this simple trial, in less than a month the difference will be discernible; the cattle to which the salt is given will shew it in their looks, in the sleekness of their coats, in their growth, and in their strength and firmness of labour. He adds, that with little more than half their usual food all these effects will be produced.

In order to establish his third proposition, he appeals to the practice about Arles, where the cattle have as much salt as they will eat, and none are so healthy or thrive so fast as those that eat most of it. It is of course supposed that there can be no doubt of the good effects of salt, in the feeding or fattening cattle; but the manner in giving it to the labouring cattle is not clearly explained. It is stated, that in eight days a stock of three hundred ate fifteen pounds of salt, being one pound to every score; and it would seem that the whole quantity was given in one day, as the farmer is cautioned against letting the sheep drink on the day the salt is given, suggesting at the same time how much it sharpens their appetites.

But the experiments of Mr. Cartwright in respect to the effects of salt, when mixed with the food of animals, have not been extended to sheep, as he did not apprehend that a few limited experiments would either throw new light upon a subject which has already been sufficiently discussed, as applied to those animals, or furnish the public with facts of which it is not already in possession. His experiments have, therefore, been confined to hogs and cows. It is stated that on July 23d, 1804, three hogs of the same litter, about eight months old, were put up to fatten. Their respective weights were as follow:

No. 1.	44 lbs.
2.	47 lbs.
3.	40 lbs.

And that from the 23d of July till the 7th of August, they were fed with barley-meal mixed up with water, during which time they consumed three bushels and a half of barley, and gained in weight as follows:

No. 1.	12 lbs.
2.	10 lbs.
3.	5 lbs.

But that from the 3d of August to the 21st, they had salt mixed with their food, of which they consumed a quarter of a pound *per* day. The food consumed was four bushels, they had gained upon the last weighing as under:

No. 1.	18 lbs.
2.	22 lbs.
3.	14 lbs.

However, that from the 21st of August to the 3d of September, the salt was discontinued, in which time they eat four bushels and a half of barley-meal, and their increase of weight was:

No. 1.	24 lbs.
2.	21 lbs.
3.	21 lbs.

But from the 3d of September to the 17th, they had salt as before, and their consumption of food was the same as during the last fortnight, namely, four bushels and a half of barley-meal. Their gain of weight was,

No. 1.	31 lbs.
2.	19 lbs.
3.	19 lbs.

They were then slaughtered.

And it is remarked that it did not appear that the salt had any operation either in promoting thirst, or stimulating their appetites, the consumption of food being nearly the same whether salted or not; neither does it appear that the salt had any influence on their fattening; perhaps the quantity allowed them was too little, and yet he should think not, as there was enough to make their whole mass of food sufficiently savory to the human taste. But in trying this experiment he did not confine one parcel of hogs to salt, and another to unsalted food. This mode of trying experiments is always uncertain, as there will be frequently habits and tendencies in the individual animals which will vary the results, and prevent their being uniform. The fairest way, and that which is the least liable to error, is to compare each animal with himself, by feeding him at one period with one kind of food, and then for an equal period with another. If this principle, which he has proceeded upon, be right, there is nothing in these experiments to encourage the practice of administering salt to hogs with a view, at least, to increase their tendency to fatten: how far it may contribute to keep them in health, is a different question, and on which years of experience may probably be necessary to decide.

It is also stated that on the 9th of October 1804, his experiments on cows commenced. On that day two Welsh heifers, one of which had calved about five months, the other three, were confined to the house, and fed with hay for the space of one fortnight. The hay they consumed during that time was four hundred weight nineteen pounds, and the milk they produced was thirty-six gallons three quarts. They had then for the next fortnight salt mixed with their hay, the hay being first slightly moistened with

water, and the falt fprinkled over it; in which time they confumed four hundred weight forty-two pounds of hay, and feven pounds of falt. The milk produced was thirty-feven gallons. For the next fortnight, namely, from the fixth to the twentieth of November, the falt was omitted, and their food was four hundred weight and one quarter of hay, and two hundred weight and a half of cabbages. The produce of milk in that fpace of time was fifty-four gallons three quarts. From the twentieth of November, their food was the fame as before, with the addition of half a pound of falt *per* day. The produce of milk was fifty-feven gallons one quart. It is here noticed that it will be recollected that falt feemed to have no tendency to promote thirft, or to increafe appetite in the hogs; yet on the cows its effects in one refpect was very perceptible, for during the period they had falt they drank three gallons a day each more than at other times. It is therefore fuppofed that falt may poffibly promote digeftion, (notwithftanding its antifeptic quality,) by ftimulating the falival glands, and the glands yielding the gaftric juice, and by introducing an increafed difcharge of their refpective fluids, fo neceffary to the folubility of the different fubftances received into the ftomach, before they can be admitted into the lacteals. And it is fuggefted that though there may be nothing in the foregoing experiments to lead us to fuppofe that falt has any other tendency to promote a difpofition in animals to fatten than as it may contribute to their health, by aiding their digeftion; yet it is probable that, when adminiftered to animals yielding milk, it may contribute in fome fmall degree to increafe that fecretion; and this it may do by promoting thirft, which induces the animal to drink copioufly, in confequence of which the fecretion of milk, as well as all other fecretions of the fluids, may be augmented. Perhaps, alfo, it may have a ftimulating influence on the lacteals themfelves. But that after all, admitting thefe experiments to prove that falt increafes, in fome fmall degree, the production of milk, when that increafed quantity is balanced againft the price of the falt, the dairy-man will find himfelf no gainer by fuch means.

Thus, notwithftanding there does not feem any thing in thefe experiments, either with hogs or cows, to encourage the practice of giving falt to animals, with a view to increafe their difpofition to fatten; yet it would be temerity to affirm that it is entirely ufelefs. From the avidity with which moft, if not all, kinds of graminivorous animals, whether in a ftate of domeftication or otherwife, are known to eat falt, whenever it comes in their way, it is reafonable to conclude that the propenfity has not been implanted in them in vain. But from whatever caufe its falutary effects may be fuppofed to proceed, whether (as was hinted at before) from its promoting digeftion, and an increafed fecretion of fluids, or from any other action it may have on the animal economy, it muft be left to an experimenter more fuccefsful than he has been, to afcertain the matter in a more perfect manner.

But with regard to fheep, it is well known that falt has long been made ufe of with advantage in preferving the health and condition of the animal; and that the inconvenience of wet, moift, and otherwife unfavourable land for fheep, may in a great meafure be obviated, by having recourfe to the giving of falt to the animals. It is indeed the common management, in almoft every country but this. The proper mode of giving it is in fhallow troughs, being allowed as much as they will take, which is in common but very little, though they are extremely fond of it. Under unfavourable feafons, and where the foil, food, and climate, are not well fuited to them, the ufe of this material has been found of great fervice. However, in Mr. Fenna's different trials with this material for fheep, whether fcattered in different parts of their pafture, or fprinkled upon other portions, the animals do not feem to have been much attracted by it; as they fcarce did any thing more than fmell to it, and quit the place where it had been depofited. This might, however, arife from their natural timidity, or their want of being accuftomed to it; as many animals are fhy in taking new forts of food, till they get a fort of tafte for them. This is the cafe with oil-cake, and fome others.

But it has been fuggefted by baron Schultz, in the firft volume of Communications to the Board of Agriculture, that it deftroys the fafciola hepatica, or fluke-worm, in fheep. And for this purpofe fome have recommended, according to Dr. Darwin, one ounce of falt to be given every day, diffolved in water; but that it is probable that it might be ufed with greater advantage, if hay was moiftened with the folution, which would thus, at the fame time, fupply them with better nourifhment than generally falls to the lot of thofe difeafed fheep, on the fuppofition that they would eat it. But as they take it readily in the manner that has been mentioned above, it may anfwer the intention in that very convenient method very well.

This fubftance, on the whole, befides its effects in other ways, as feen above, has the property of moderating the heat in hay-ftacks, preferving the green colour, and improving the quality of it. See Hay, &c.

In the early ages of the world falt was regarded as a fymbol of extreme fterility. And we read of princes, who, in token of their indignation, fowed grounds with falt to render them barren. See Judges, ix. 45. Deut. xxix. 23. Zephan. ii. 9.

Virgil, Georg. lib. ii. reprobates a falt foil as occafioning the degeneration of fruit-trees, and admitting no melioration from ploughing.

Pliny, fpeaking of foffile falt, affirms, that every place in which it is found is barren, and unfit for vegetation. And Plutarch obferves, that the Egyptians believed falt to be the fpittle or foam of the giant Typhon, the great enemy of their gods; and hence, he adds, they held it in the greateft abhorrence.

In later times, however, falt has been frequently ufed as a manure with great fuccefs. It has been the cuftom, ever fince the time of Henry III. at leaft, for the farmers on the Cornifh coaft to manure their land with fea-fand, in which fea-falt is fo copioufly mixed, that in many places it is ufed to be extracted from a ley made of fand. When the fand has been long expofed to the air, it proves lefs ufeful and enriching, which fome have attributed to its having been deprived of a good part of its falt by the dews and rains. This practice of manuring lands with fea-fand has, within thefe few years, been introduced with advantage, in other parts of Great Britain. The Chefhire farmers purchafe no inconfiderable quantity of refufe falt from the falt-boilers: they mix it with dung, and it makes an excellent manure. At Northwich alone, there were fold, a few years ago, near 3000 tons of it in one year, for the ufe of the farmers in that and other counties.

In Chefhire, and other counties, they make a great ufe of the water of their falt-fprings, as a manure for their lands. They let out the water of thefe fprings for a certain time upon the lands, after there has been rain, and by this means the quantity of falt they contain is fo blended with the rain-water, that it is too weak to hurt the corn or grafs, and yet ftrong enough to kill worms and other vermin, and to improve vegetation.

On the other hand, when the foil abounds with rufhes and

weeds, it is cuſtomary in Cheſhire to lay a quantity of rock-ſalt upon it, as it is found utterly to deſtroy every vegetable. And Mr. Tull, obſerving that common ſea-ſalt is deſtructive to almoſt all plants, except thoſe which naturally grow in the ſea-water, or on the ſhores, invented a method of determining how far the horizontal roots of plants run, by burying ſalt at a diſtance from them.

From the above obſervation it ſhould ſeem, that ſalt, when uſed in ſmall quantities, is a good manure, and, when in large ones, a real poiſon to vegetables.

Some of the African and Arabian deſarts are thought to be barren by their having too much ſalt in them; whilſt many parts of Barbary are reckoned to be peculiarly fruitful, from their containing a leſs quantity of it. As ſalt, in ſmall quantities, is known to accelerate the putrefaction of animal ſubſtances, and when in larger, to retard it, and thus is uſeful in aſſiſting the organs of digeſtion in men and other carnivorous animals, as we have already obſerved, ſalt applied in like manner, as a manure, may be found very beneficial; not from its entering as an aliment into the ſubſtance of vegetables, ſince there are many experiments tending to prove that no kind of ſalt can of itſelf become the food of plants; but from its efficacy in reducing weeds, dried herbage, dead roots, &c. into a putrid oily maſs; the fructifying virtue of oily compoſts being now generally acknowledged: but when it is uſed in a large proportion, by preſerving theſe matters from corruption, and drying up or hardening the fibrous capillaries of the roots, ſo that they become unfit for ſucking in nutriment, the fertility of the ground is diminiſhed, or wholly deſtroyed. As to the fertility of lands overflowed by ſea-water, it may be partly owing to the ſlime and mud left by it, and partly to the ſalt contained in it, which, being in a ſmall quantity, may contribute to the putrefaction of the effete vegetable roots, and the conſequent production of an oily compoſt.

There are no lands that fatten cattle ſooner than thoſe paſture grounds which are thus, at times, overflowed by ſalt-water: ſuch, *e. g.* are the paſtures at Erith, near the Thames, which are ſometimes overflowed at ſpring-tides. Some farmers have tried the ſcattering of ſalt over their corn-fields, as ſoon as ſown, in the quantity of two buſhels to an acre, with good ſucceſs: and this quantity may be productive of all the advantages which ariſe from the occaſional overflowing of high tides, or natural ſalt-ſprings.

Salt is uſed *ſymbolically* and *metaphorically*, by ſacred and profane writers, in a variety of reſpects. Accordingly we find it uſed as the ſymbol of wiſdom, Mark, ix. 50. Col. iv. 1.; and hence we read of Attic ſalt, denoting wit or mental intelligence. Salt is alſo uſed as a ſymbol of incorruption and perpetuity, Numb. xviii. 19. 2 Chron. xiii. 5. It is alſo metaphorically uſed to ſignify barrenneſs or ſterility, Judg. iv. 15. Zephaniah, ii. 9. Jer. xvii. 6. Salt is likewiſe the ſymbol of hoſpitality, and alſo of that fidelity which is due from ſervants, friends, gueſts, and domeſtics, to thoſe who maintain them. Thus the governors of the provinces beyond the Euphrates, writing to king Artaxerxes, tell him, "becauſe we have maintenance from the king's palace, &c.;" which in the Chaldee is thus expreſſed, "becauſe we are ſalted with the ſalt of the palace." (See Ezra, iv. 14.) Among the nations of the Eaſt Indies it is ſaid to be a common expreſſion, "I eat ſuch an one's ſalt," for "I am fed or maintained by him."

Salt, in *Chemiſtry*, &c. See Sal and Salts.

Salt-*Brine Springs*, in *Rural Economy*, ſuch ſprings, openings, or pits, as afford a watery fluid, ſtrongly impregnated with ſalt or ſaline matter. The ſalt obtained from the water of ſalt-wells and ſprings, is denominated *brine* or *ſpring* ſalt. Great quantities of this ſalt are made in moſt of the inland countries, as in Germany, Switzerland, Hungary, and in ſome parts of France and England.

In Somerſetſhire, Cumberland, Weſtmoreland, Durham, and Yorkſhire, there are many ſalt-ſprings, but they are either too weakly impregnated, or ſituated where fuel is ſcarce, and for theſe and other reaſons are not worked; but in other parts of England there are many rich and valuable ſalt-ſprings, which are worked to great advantage. Of theſe, ſome are ſituated in Staffordſhire, a great many in Lancaſhire, but the chief are thoſe at Droitwich in Worceſterſhire, and Northwich in Cheſhire; about which laſt place there are many rich mines of foſſile ſalt, above and beneath the beds of which the ſalt-ſprings are uſually found.

At Namptwich, in the laſt county, there are alſo ſome ſalt-wells, which have been of very long ſtanding, being ſuppoſed by many to have been worked in the time of the Romans. The brine of theſe ſprings is found to differ very greatly in its ſtrength and qualities; ſome yielding much more ſalt than others, and the ſalt extracted from ſome of them being found improper for many uſes, for which that of others ſerves very well.

The brine of Barton and Northwich is almoſt fully ſaturated with ſalt, a pound of it yielding, as ſome have ſaid, ſix ounces of ſalt; but this cannot be ſtrictly true; for, allowing that 16 ounces of water can diſſolve ſix ounces of ſalt, and no more, it muſt follow that no brine-ſpring can yield ſix ounces of ſalt from a pint of brine; becauſe 16 ounces of water impregnated with ſix ounces of ſalt, conſtitute a ſaturated brine, weighing 22 ounces; and, therefore, by the rule of proportion, if 22 ounces of brine contain ſix ounces of ſalt, 16 ounces of brine will contain $4\frac{4}{11}$ ounces of ſalt. Hence we may infer, that the ſtrongeſt brine-ſprings will not yield above one quarter of their weight of ſalt. Accordingly, Dr. Leigh (Hiſt. of Lancaſhire, p. 43.) informs us, that ſome of the ſtrongeſt ſprings at Northwich yielded ſeven or eight ounces of ſalt from a quart of brine; but a quart of brine weighs conſiderably more than 32 ounces, the weight of a quart of water: ſo that the Northwich ſprings, from this account, do not yield a quarter of their weight.

The brine of Droitwich, Upwich, and Middlewich, contains about one-fourth of ſalt: ſome of the ſprings at Namptwich yield a ſixth part of ſalt; and thoſe of Weſton, in Staffordſhire, afford only one-ninth part. In England, we ſeldom boil weaker brine than the laſt; but in Germany, and ſome other places, where ſalt is ſcarce, they work ſprings, whoſe water is not impregnated more highly than the common ſea-water, containing about $\frac{1}{30}$ ſalt.

Here we may obſerve, that ſea-water, brine-ſprings, and rock-ſalt, generally contain, beſides common ſalt, various other earthy and ſaline ingredients, ſuch as calcareous earth, magneſia, Epſom ſalts, ſelenites, Glauber's ſalt, fixed alkali uncombined with any acid, &c. Theſe ſubſtances are foreign to the nature of the ſalt, and injure its quality; and hence it muſt appear, that common ſalt may have very different properties, according to the quality of the water from which it is made, or ſkill of the ſalt-maker in ſeparating theſe heterogeneous ſubſtances from it.

Although ſprings of the kind above-mentioned exiſt in ſeveral different parts of our own country, in different degrees of ſtrength, and of different qualities, yet they are perhaps at preſent no where wrought for the purpoſe of obtaining ſalt from them, in any quantity, except in the county of Cheſter. They are, however, highly intereſting and important to that diſtrict in ſeveral different points of view.

The intelligent author of the corrected account of the agricultural ſtate of that diſtrict, ſays that the principal

brine-ſprings in it are found in the valleys through which the river Weaver, and the ſmall rivulet the Wheelock, have their courſe; and, for the moſt part, near the banks of them. If a weak ſpring of this nature at Dunham, near the Bollin river, be excepted; and the ſprings at Dirtwich, in the moſt ſouthern part of the county; no others, it is ſaid, have ever been worked. By their means, it is ſuppoſed, an importance is given to the firſt mentioned river, that it would not otherwiſe poſſeſs; and that there is probably a greater bulk of carriage on that ſtream, than on any other river in the iſland, which is of itſelf ſo little conſiderable. Tracing the courſe of this river from its ſource, at the Peck-ferton hills, no ſprings ſtrongly impregnated with ſalt are ſaid to be found near it, until the town of Namptwich is approached. But that brine does exiſt as high up as Brickley, though it has not been aſcertained at what depth, or of what ſtrength, ſeems probable, it is ſaid, from a ſinking of the ground, and the conſequent filling of the cavity with this ſort of fluid, which took place in its vicinity in the year 1657; accounts of which are given by Dr. Jackſon, in the Philoſophical Tranſactions, and more minutely by Childrey, in his Britannica Baconica. Leland has alſo, it is obſerved, given the hiſtory of a very ſimilar occurrence at a ſtill earlier period, a few miles ſouth of this. It is related by him, that "about a mile from Combermere abbey, part of a hill, with trees upon it, ſuddenly ſunk down, and was covered with ſalt-water, of which the abbot being informed, cauſed it to be wrought; but the proprietors of the wiches compounding with him, he left off working." It is likewiſe added, "that this ſalt-pool ſtill continued in his time, but that no care was taken of it."

It is further ſtated, that a few miles lower down the Weaver than Brickley, in Baddiley, and one or two adjoining townſhips, ſprings are met with variouſly impregnated with ſalt. Brinefield is, it is ſaid, the name given to different incloſures in Baddiley. And where the river takes a northerly direction at Audlem, brine is, it is ſaid, met with on each ſide of it, and may be found, on ſinking near its banks, all the way from thence to the town of Namptwich. About the midway between the former place and Namptwich there is a farm, it is remarked, which ſtill retains the name of Brine-pits farm, where ſalt was formerly manufactured. Alſo a little further down, brine was found, and ſalt made, on each ſide of the river, at Auſtaſton and Baddington, as ſtated in King's Vale Royal. However, at the preſent time, it is aſſerted that none is manufactured until the town of Namptwich is reached, where a great many ſalt-brine ſprings preſent themſelves. Continuing the ſame courſe down the river, brine is again found at Winsford. And betwixt Winsford and Northwich, attempts have been made to get down to it; but theſe have hitherto, it is ſaid, been rendered unſucceſsful by the quantity of freſh water which has been met with. It is ſtated to be again found at Lettwich, in the angle between the Dane and the Weaver rivers; at Northwich; at Witton, half a mile north of the former of theſe places, on a ſmall brook of the ſame name, which falls into the Weaver at Anderton, a townſhip about a mile below Northwich. Alſo at Barnton, a mile ſtill lower down the river, a weaker brine has been found; and again at Saltersford, about a mile below the above place. Two miles ſtill lower, in Weverham, brine has likewiſe been found, which was worked, it is ſaid, as early as the time of William the Conqueror; but it does not appear, it is remarked, that any has been diſcovered below this place.

And in following the courſe of the little ſtream, the Wheelock, brine is, it is ſaid, firſt met with at Lawton, on the very confines of the county; then three or four miles lower, at Roughwood, in the townſhip of Bechton; again at Wheelock; and, laſtly, at Middlewich, where the Wheelock falls into the Dane. It is remarked that no brine has been found in the valley through which the Dane flows from Middlewich to Northwich: however, higher up this ſtream, in the vicinity of Congleton, ſome of the incloſures have, it is ſaid, the name of Brine-field, Brine-hill, &c. whence it may be concluded, that brine has ſome time or other been diſcovered there in ſuch places.

But though the places which have been noticed are the only ones where brine has been found, and works for its evaporation erected, there is little doubt, it is ſuppoſed, but that it might be met with in almoſt every part of the valleys through which the Weaver and the Wheelock rivers take their courſe, did not the freſh-water ſprings prevent the acceſs to or the coming at it.

It is ſtated that the depth from the ſurface at which the ſalt-brine ſprings are found; the level they take when the ſtratum which immediately confines them is penetrated; and the abundance of the brine which they contain or afford, are extremely various. About the town of Namptwich, the brine is met with, it is ſaid, about ten or twelve yards from the ſurface; and that in ſinking for freſh water, it is neceſſary to do it with caution, in order that the brine may be avoided. It is noticed, that in ſinking for the foundation of a bridge, ſome few years ago, juſt above this town, a very copious ſalt-brine ſpring was found about eight yards from the ſurface; and that the workmen were much incommoded by it. The brine-ſprings moſtly riſe near to the ſurface. When Winsford is reached, to which place the river Weaver is made navigable, the brine is found, it is ſaid, at a much greater depth from the ſurface; and that it is generally neceſſary to ſink from fifty-five to ſixty yards before it is met with, when it is uſually found in great abundance. It has its level twelve yards from the ſurface. Near Northwich it is ſtated to be found at a depth from thirty to forty yards, the ſprings being very fluent; and its level is about twenty yards from the ſurface. At Witton it is met with at about the ſame depth, and riſes much to the ſame level, the ſprings being equally copious. However, through the whole of Anderton, the quantity of brine is ſaid to be the moſt abundant; at the higher end of that townſhip it is obſerved to be found about forty yards from the ſurface, and that the level is nearly the ſame as that at Witton. Somewhat lower down, it is ſaid to be neceſſary to ſink from fifty to fifty-five yards before it is met with. Still keeping the courſe of the river, at Barnton, about a mile below Anderton, on ſinking ſixty yards, and boring fifty yards below this, it is noticed, that a very weak brine was diſcovered, and that in ſmall quantities only.

In tracing the different ſalt-brine ſprings along the little ſtream of the Wheelock, it is ſaid to be found, that at Lawton they are met with about eighty-five yards from the ſurface, and have their level at ſeventy yards. The ſprings here, it is remarked, are much leſs copious than many of thoſe on the Weaver. At Roughwood, the brine is fifty yards from the ſurface, and riſes fifteen yards; the ſpring is by no means abundant, and it is often pumped dry. At Wheelock it is noticed to be found at the depth of ſeventy yards, and that it riſes within thirty yards of the ſurface; the ſprings being very copious. At Middlewich, however, the brine is, it is ſaid, at different depths, as from thirty-five to eighty-four yards; in one pit, in which it is found at ſeventy yards depth, it riſes, it is ſaid, to the ſurface. But, it is remarked, that the ſprings here are by no means ſo fluent, and are occaſionally pumped until they are quite dry.

In regard to the *diſcovery* of the ſalt-brine ſprings in this

diſtrict, and the time when they were firſt worked, it is ſaid that we are without any certain accounts. It is thought, however, that there can be little doubt, but that at a very early period ſalt muſt have been procured from the brine-ſprings which found their way to the ſurface. This, as has been ſeen above, is particularly the caſe with the ſprings in the vicinity of the towns of Namptwich and Middlewich; and it is known from Doomſday-book, it is ſaid, that, at the time of Edward the Confeſſor, brine-pits were wrought at all the wiches in this diſtrict. It would appear, however, it is obſerved, that, even ſeveral centuries afterwards, the art of making ſalt was very imperfectly underſtood in any part of this country; and that the quantity manufactured was very inconſiderable. And it is further ſtated, that Henry VI., having been informed that a new method of making ſalt had been invented in the Low Countries, by which it might be made more abundantly in this country than had hitherto been the caſe, invited John de Sheidame, a gentleman of Zealand, with ſixty perſons in his company, to come into this country, and inſtruct his ſubjects in the new method of making ſalt, promiſing them protection and encouragement. But whether they came, or what their improvements were, does not appear: however, it is probable that theſe were not of much importance, or that they were loſt, as we find the Royal Society, ſoon after its inſtitution, very intent upon improving the art of manufacturing white ſalt, and publiſhing, towards the cloſe of the ſeventeenth century, the accounts or hiſtories of ſeveral modes of making it; particularly Dr. William Jackſon's account of the brine-ſprings, and the method of making white ſalt at Namptwich, in this country; and Dr. Thomas Raſtel's account of the manufacture of it at Droitwich, in Worceſterſhire. However, theſe are conceived to be rather reports of the methods of manufactures then uſed, than ſuggeſtions of improvements. The ſalt made in this country was ſtill, it is ſaid, conſidered inferior to that made abroad; and what was manufactured in Cheſhire was confined to the ſupply of its own conſumption, and that of a few neighbouring counties or diſtricts.

But the want of knowledge in the manufacture, and the ſuppoſed ſuperiority of foreign over Engliſh ſalt, it is obſerved, attracted, in the beginning of the laſt century, the attention of the houſe of commons; and Mr. Lowndes, a Cheſhire gentleman, received a reward from parliament, in conſideration of his making known ſome improvements he was thought to have made in the manufacture of ſalt. Soon after which the late Dr. Brownrigg publiſhed his ingenious and philoſophical work on "the art of making common ſalt," in which, in addition to a full and detailed account of the proceſſes in the manufacture of it, at that time uſed, he ſuggeſted, it is ſaid, a variety of alterations and improvements. Some of theſe were, it is obſerved, adopted, though not to the extent which was admitted of by the ſtate of the manufacture. In conſequence, however, it is thought, of theſe and various ſubſequent improvements, joined to the increaſed commercial ſpirit of the country, and the facility of communication with the port of Liverpool, by rendering the river Weaver navigable for veſſels of conſiderable burthen from Northwich and Winsford, the manufacture of white ſalt in Cheſhire, as well for home conſumption as for exportation, has exceedingly increaſed in the courſe of the laſt century, more particularly towards the cloſe of it; and the ſupport of it is now become, it is thought, an object and matter of the firſt conſequence, not only to the county itſelf, but to the whole nation.

Therefore ſalt-brine ſprings appear to have exiſted, and to have been wrought in this diſtrict, from the earlieſt periods of the hiſtory of this country, while the diſcovery of the beds of foſſile ſalt in it are only of late date. See Rock-*Salt*.

In regard to the origin and ſtrength of theſe ſalt-brine ſprings, it may be obſerved, that the notions concerning the former were, it is ſaid, extremely erroneous and abſurd until the diſcovery of the beds of foſſile ſalt; but that ſince that period, no doubt has been entertained that their ſaline contents are derived from the water of ſprings, or rain-water, coming upon, or penetrating down to the ſurface of theſe rocky beds, or the heads of the rock, as they are commonly termed, and thus effecting the ſolution of a certain portion of them with which they come in contact. With reſpect to the latter, the quantum of ſuch ſolution, or the ſtrength of the brine, various circumſtances will, of courſe, it is obſerved, influence it; but moſt particularly, the extent of ſurface of the rocky ſaline bed, which is expoſed to the action of the water; as the greater this is, the more completely the water and the rocky bed are brought into contact, the longer and more perfect the ſolution which takes place, and the ſtronger the brine or ſalt-ſpring. But, independently of ſuch an immediate operation, the ſtrength of the brine will, it is ſaid, be varied by the manner in which any pit is worked, and the circumſtances attending the raiſing of the brine; for if it be pumped up ſeldom, it will be found to be weaker than it would be, were it drawn up more frequently. Dr. Jackſon found, that a quart of brine, when the pit had been drawn off three or four days, to ſupply five or ſix wich-houſes, yielded an ounce and a half more ſalt than at any other time, when it had a reſt of ſomewhere about a week. And it is ſaid, that it has been noticed at ſeveral ſalt-ſprings, by Dr. Brownrigg, that the brine is much ſtronger at the bottom of the pits than near the ſurface; alſo in dry weather, than in wet; and when the pits are conſtantly drawn, than when little brine is taken out of them. The explanation of which is conſidered to be this, that the water which finds its way to the layer or bed of foſſile ſalt, probably remains, in a great degree, at reſt, until put in motion by raiſing the brine; while in this ſtate, the portion of it which is in immediate contact with the rock becomes ſaturated; but acquiring at the ſame time a greater degree of ſpecific gravity than it had as pure water, it thereby prevents the water above from ſinking down ſo as to act upon the rock; and the ſum of ſolution is conſequently leſs than where the pit is frequently worked, and the rocky ſaline ſubſtance expoſed to a more conſtant action of the water. This, it is obſerved, is particularly the caſe in ſuch brine-pits as are not immediately connected with any others; and that the ſame obſervations will be applicable to thoſe pits which have a communication; with this difference only, that the mode of working in one pit is to be taken into conſideration in the effect produced on the ſtrength of the brine in another, independently of its own particular operations. It is ſtated, that moſt of the pits in the vicinity of Northwich and Winsford in the above diſtrict, have ſuch a communication at the rock-head, as is rendered ſufficiently apparent by the brine in one pit having its level lowered, when another pit is at work at ſome diſtance. At the former place this has been further evinced, it is ſaid, when the brine has found its way into the cavity of a rock-ſalt pit, an accident which has not unfrequently occurred. In ſuch caſes, it is obſerved, ſix or eight brine-pits, at the diſtance of nearly a mile from each other, have often been laid dry, and have continued ſo until the rock-pit has been filled, and the brine has again found its level. Even on ſome occaſions, where the cavity of the rock-pit has been large, it is remarked, that four or five weeks have elapſed before this has been fully accompliſhed. The ſtrength of the brine will alſo, it is ſaid, be further

materially affected by the quantity of fresh water which finds access to it, either directly through the sides of the shaft out of which the brine is drawn, or by any fissures, cracks, or openings in the earth with which these are nearly connected. The proportion of salt which is held in solution, in such cases will, it is said, bear a ratio to the fresh water thus introduced, and to the subsequent opportunity this has of acting upon the rocky substance. These circumstances are therefore all highly necessary to be considered in the working of salt-brine springs.

In respect to the quantity of salt which a given portion of water, fully saturated, will hold in solution, very different estimates have been formed; which are supposed to have been caused by confounding given quantities of brine with the same measures of water, and the want of proper discrimination between the quantities of salt contained in the one, and that capable of being dissolved by the other; as well as from the different state of the salt used in making the trials, in which there may have been variations in dryness, and more or less of the water of crystallization. But the result of the most correct trials shews it to be not quite six ounces in sixteen of water, avoirdupois weight. In the forming of establishments for the making of salt from brine-springs, this is, of course, of material importance, as the first points to be considered are unquestionably the strength and purity of the brine which is to be employed. However, notwithstanding these circumstances, the advantages derived from several other adventitious ones may, it is said, render it better worth while to prepare the article from a weaker brine in one situation, than from a stronger one in another. The chief and most material point which has any influence in this business, after those of the strength and purity of the brine, is said to be the convenience which is afforded of water-carriage for sending away the manufactured material, and for the ready conveyance of fuel to the works. The expence and capability of supply of this last article are also necessary to be considered. And the fluency of the spring is another consideration which, it is noticed, Dr. Jackson has observed, "may be rich or poor, in a double sense; for a spring may be rich in salt, but poor in the quantity of brine it affords." The opportunity of strengthening a weaker brine with rock-salt, may likewise, it is said, render it more advantageous to work this, than a stronger brine differently circumstanced.

In respect to strength and purity, the greater proportion of the brines of the above district are concluded, from different trials, to possess them in a very superior degree; and that many of those which are less impregnated with salt, have rock-salt at no great distance from them, for affording the ready means of strengthening them; while the springs are in general copious, and fuel, especially coals, readily procured, though of late at a much more increased rate than formerly, notwithstanding the more extended navigation of the principal river, and every convenience of water-carriage furnished by a neighbouring canal.

It is further noticed that the workmen, or the *wallers*, as they are denominated from the bank or wall they raise by the salt rubbish round the pits, commonly make their estimate of the strength of brine from its specific gravity; a new-laid egg being their usual hydrometer, which sinks in pure water, but is suspended when the water holds a small portion of dissolved salt in it; and has a larger or smaller extent of its surface exposed, as the brine contains more or less salt in solution. They have also an instrument of the above kind graduated upward, like that for spirits, which is occasionally employed, the zero point of which is completely saturated or *leach* brine; however, by this, it is said, they only know the comparative strength of the different brines, and are not enabled to ascertain the exact proportion of salt contained in any given quantity of liquor.

It is however stated, that, from the table in Watson's Chemical Essays containing the specific gravity of water impregnated with different quantities of salt, from the one-third down to the one thousand and twenty-fourth part of the weight of the water, by knowing the same sort of gravity in any brine, a pretty exact estimate may be formed of the amount of the salt it contains. The French, it is observed, employ Baumé's instrument for this purpose, as being, from its ready application, the most useful and convenient. And with the same hydrometer, nicely adjusted and regulated with every possible care in other respects, the writer found by his trials that the strength of several of the Cheshire brines was from 21.250 to 25.625 *per cent.* of pure salt, and in one instance from 25 to 26.566 *per cent.*; or that in an ale-pint there was contained from 4 oz. 15 dr. to 6 oz. 2 dr.; and in one case from 6 oz. to 6 oz. 6 dr.; and the proportion of earthy salts contained were from 6.25 to 2.500 *per cent.* Some of the brine-springs are noticed to have a greater specific gravity than that of a saturated solution of muriate of soda in pure water; which was found by the above hydrometer to be, when cold, 27.812 *per cent.* of the salt; an ale-pint of the London standard brass measure, containing 6 oz. 12 dr. By referring to the work the quantities will be seen minutely put down, with the names of the different brine-springs to which they relate, and many other interesting particulars.

And a comparison of the strength of the brine-springs in the above district, with that of similar springs in France, may be formed by the account given by citizen Nicholas, an associate of the National Institute, in a memoir on the national salt-works in the departments of La Meurthe, Jura, Daubs, and Mont Blanc; who was required, by a decree of the committee of public safety in August 1795, to visit such works, and collect all the necessary information concerning their actual situation, and the means of their improvement. It would appear, it is said, that there are three of these establishments in the first, as at Chateau Salins, at Moxenvie, and at Dieuze; two in the second, as at Salins, and Mont Morot; one in the third, at Arc; and two in the last, as at Montiers, or Mont Salin, and at Conflans. At the three first places, the brine pretty regularly contains, it is observed, from 13 to 14 *per cent.* of muriate of soda, though, after long pumping, it comes up stronger. At the two second places, the average degree of saltness in the former is 11.86 of the hydrometer; and that of the latter from $1\frac{1}{3}$ to $8\frac{1}{2}$ of it. At the third place, the brine contains from $3\frac{2}{3}$ to $7\frac{1}{4}$ *per cent.* of the same salt. And in a particular trial with the brine at Chateau Salins, the result was, that one pound of water gave 1 oz. 7 gr. of pure salt; 25 grains of selenite; 75 grains of Glauber's salts; and $81\frac{1}{2}$ grains of muriated lime and magnesia.

In respect to the *rent* of brine-springs, from Doomsday-book, it is said to appear that the king had formerly a claim on all those in the above county. That, in the time of Edward the Confessor, there was a brine-spring at Namptwich, and eight salterns betwixt the king and earl Edwin; of which the king bore two-thirds of the expences, and received two-thirds of the returns; the earl the other third. Besides, the earl had a saltern for the particular use of his own family: if, however, he sold any salt from it, the king had two-thirds of the receipts, the earl one-third. Several private individuals had also, it is said, salterns for the use of their own families; but if they sold any salt, a certain sum was paid to the king.

However, no right over these springs is now, it is said, claimed by the crown; they being solely the property of the owners of the land in which they are found. Few of them, however, are occupied by the land owners; they being commonly let out to tenants, either at fixed annual rents, without any restrictions as to the working of them, or at rents proportioned to the extent of the manufacture, and the quantity of salt produced.

In order to prepare the salt, the brine is raised from the pits in which it is found, by being pumped up into cisterns, or reservoirs formed near the works. In such situations as admit of the aid of a stream of water, it sometimes is raised by that means, as is the case at different places. Where such assistance could not be had, it was formerly the custom to draw it up by horses. However, in Camden's time horses were not had recourse to for this purpose, as he observes, that "at Northwich there is a deep and plentiful brine-pit, with stairs about it, by which, when they have drawn the water in their leathern buckets, they ascend half naked to their troughs, and fill them, from whence it is conveyed to the wich-houses." The demand for salt increasing, small wind-mills were in addition employed for this use; and as the consumption became still larger, a variety of inconveniencies were experienced from trusting to so uncertain a machine, which ultimately led to the use of steam-engines, and consequently, at almost all the newly-erected works the brine is raised in this way.

It is noticed that the *reservoirs*, into which the brine is pumped up, are either large ponds, formed in clay, and mostly lined with brick, being capable of containing the consumption of several weeks; or they are wooden cisterns, pitched within, fit for holding the supply of it for the consumption of only a few days.

Though it has been seen that many of the brines contain very large proportions of salt, so as to be nearly saturated in some cases, they will all dissolve an increased portion of salt to some extent; and as it is of great importance in regard to the economy of fuel, to have the smallest possible quantity of superfluous water to evaporate, it is constantly an object with the manufacturer to have a fully saturated brine. In cases, therefore, where the brine is weak, or where there is the convenience of saturating a brine already strongly impregnated with salt, this is done by putting rock-salt in the cistern into which the brine is pumped, and permitting the liquor to act upon it until it becomes completely saturated. For this purpose a strong wooden frame is fixed in the cistern, at about half its depth, upon which the rock-salt is thrown; and the earthy residuum is occasionally removed from it, after the whole of the salt has been dissolved. Water slightly impregnated with salt, in other works, is also improved and brought to a perfect state of saturation in the same way.

From these reservoirs the brine is, it is said, drawn, as it is wanted, through wooden pipes, or by troughs, into the *evaporating* pans, which are now made of wrought iron; the dimensions of which vary considerably, but they are mostly in new works a great deal larger than those which were in use a few years ago; usually containing from 600 to 800 superficial feet, and in one or two instances nearly 1000 feet. Their form is usually that of an oblong square, having the depth of from 12 to 16 inches. Those of the first sizes have commonly three furnaces, of from six and a half to seven feet long, and from 20 to 24 inches wide. The grates from two and a half to three feet from the bottoms of the pans. The furnace-doors single; and none to the ash-pits. Each pan is mostly partitioned out, and has a separate *pan-house*, on the sides of which are long wooden benches, more than a yard wide, for placing the salt upon in conical baskets to drain, after it is taken from the pan; these houses being covered with wooden or slated roofs, with *œuvres* to let the steam pass freely away. See the work alluded to above, and the article SALT.

The very great difference in the dimensions of the reservoirs, the pans, and other things used at present, and those which were employed two centuries ago; strongly denote the vast increase and improvement of this manufacture.

The salt is prepared from the salt-brine springs, in the above districts, into *stoved* or *lump* salt, *large-grained flaky* salt, and *large-grained* or *fishery* salt, by several different ways, or rather by the application of different degrees of heat in the process; the first sort being produced by the highest, or that of two hundred and twenty-six degrees, and the last sort by the lowest, or that of from one hundred to one hundred and ten. The intermediate degrees furnishing the other two sorts of salt, as those of from one hundred and sixty to one hundred and seventy; and of one hundred and thirty to one hundred and forty degrees of Fahrenheit's scale. See MURIATE *of Soda*, and SALT.

Though the white salt made in the above district was, little more than a century ago, scarcely more than sufficient to supply its own consumption, as has been seen, the increase which has taken place since that time has been so great, on different accounts, that the quantity disposed of for home consumption in different places is stated to have been, from six of the works, from the 24th of May 1805 to the same date in 1806, no less than 663,637 bushels, or 16,590 tons 77 bushels, which paid a duty to government of 475,728*l.* 15*s.* And though the increase has lately been so very large, there is reason to believe, it is said, that it is still capable of considerable extension. See ROCK-*Salt*.

SALT-*Brine Pits*, the shafts, pits, or openings from which the salt-brine is taken or raised. See the preceding article.

Saltpetre

SALTPETRE. See NITRAT *of Potash*, NITRIC *Acid*, POTASSÆ *Nitras*, and *Nitrat of Potash*, under SALTS. Of the chemical and medical properties of saltpetre or nitre, a brief account has been already given under the articles to which we have above referred. It remains to detail, as concisely as possible, the natural history of this substance, the mode of its manufacture, and its uses in the arts. Nitre, as a natural product, may be found in two different repositories, the first of which is lime-stones, and the second vegetable soil. The first, a calcareous repository, is either a peculiar variety of secondary floetz lime-stone, or calcareous tufa, or chalk, or indurated marle. In these rocks it occurs as a thin granular crust, or an efflorescence of minute spicular crystals, overspreading the outside, and lining the inside of natural and artificial caverns, with which these rocks abound. Hence, as it has been conjectured, it might have derived its name of saltpetre, "sal-petræ," or rock-salt. Calcareous strata containing nitre are found in various parts of South America, in some districts of France, in the county of Bamberg, and at Hamburgh, near Wurtzburg. But the most celebrated repository of native nitre is the Pulo of Molfetta, in the province of Puglia, in the kingdom of Naples. This deep cavity, in form of an inverted cone, has within it, and branching from it, several excavations, natural and artificial, the strata of which consist of hard secondary lime-stone, abounding with the remains of organized bodies. At the time when the abbé Fortis directed the public attention to them, all these caves were lined with an efflorescent crust of nitre more than an inch thick, which, after being scraped off, was again renewed within a few days in constant succession. The substance of the rock, to the depth of a foot or more, was richly impregnated with the salt which might be separated by lixiviation, but at a greater depth no nitre was found, or at least boiling water did not afford it by dissolution. A piece of this rock, however, appears by the testimony of Dolomieu, after lying for two months in a dry cabinet, to have been covered with a thin crust of nitre. Klaproth and Pelletier, having analysed the nitrous crust of Pulo, obtained the following results:

Klaproth.	Pelletier.	
425.5	407.5	nitre.
2.		muriated potash.
	26.7	muriates.
	20.8	sulphates, soluble in cold water.
254.5	96.7	sulphate of lime.
304.	410.	carbonate of lime.
986.0	961.7	
14.	38.3	loss.
1000	1000	

Another repository of native nitre is vegetable soil. Of all countries of Europe, Spain is said to abound most with this kind of soil. According to Bowles, nearly a third of the uncultivated lands in the eastern and southern provinces of this kingdom afford a rich supply of it by the following management. During the winter and spring the land is ploughed twice or thrice, to the depth of three or four inches; it is suffered to lie fallow the whole summer, and about the middle of the autumn, the soil having been thus fully exposed to the air, is lixiviated; and the liquor being boiled down in the usual manner, affords, in cooling, a quantity of nitre, mixed with from 20 to 40 *per cent.* of common salt. A considerable part of the soil in Lower Hungary is richly impregnated with nitre; and the water of several wells and springs, containing from two-thirds to four *per cent.* of this salt, is unfit for drinking. In India many of the lands, and especially those that lie in the vallies of great rivers, very much abound with nitre; and in the presidency of Calcutta alone, between 7000 and 8000 tons are annually manufactured. The saline efflorescence which covers the surface of the soil being swept off, is renewed every other day at particular seasons of the year: and that soil, in which the salt is less abundant, is raked up in small heaps, mixed with the scrapings of roads and cattle-stalls, and after being for a certain time exposed to the action of the air, lixiviated. The earthy residue is mixed with fresh earth, and after two years affords as large a produce of nitre as at first. Those nitrous soils, the acid of which is combined, for the most part, with lime instead of potash, and which, in the usual mode of treatment, yield but a small quantity of nitre, are rendered productive by the addition of wood-ashes: the carbonated alkali of the ashes and the calcareous nitrate of the soil mutually decomposing each other, and furnishing, in the result, carbonated lime and nitrated potash. Many of the soils in India, as well as those of China and other parts of Asia, require this alkaline addition. This is also the case with much of the soil in the Crimea and Ukraine. In many parts of the Crimea, those parts are selected that have been long uncultivated, and also those artificial parts that have served for burial-places and the scites of towns; and the soil being dug up, is mixed with about one-fifth, by measure, of wood-ashes, and lixiviated in perforated casks in the usual method: the liquor thus produced, after concentration by repeated lixiviations, is mixed with the mother-water of a preceding crystallization, and boiled down for 24 hours, removing from time to time the common salt and muriated potash that separate during the process: it is then transferred, while hot, into shallow coolers, in order to crystallize, which it does in 24 hours more. The rough crystals being drained, are again dissolved in water, and the product of the second crystallization is a nitre somewhat impure, and yet fit for the market. Four hundred cubic feet of the mixture of earth and wood-ashes afford 42lbs. of nitre of the first crystallization, which, by subsequent refining, is reduced to 39lbs.

After the adoption of fire-arms, the consumption of

nitre became proportionably great, and of courſe art and induſtry more actively employed in obtaining it. Different ſoils were attentively examined, and experiments were made for aſcertaining their various products. In the courſe of theſe reſearches it was found, that the ſuperficial ſoil of farm yards, of cattle-ſtalls, of cellars, of privies, and of other places long expoſed to the vapours of putrefying animal matter, afforded, when mixed with wood-aſhes and lixiviated, a conſiderable quantity of nitre. It was alſo found, that the plaiſter, mortar, and brick rubbiſh of old houſes, might, by a ſimilar treatment, yield this ſalt. In conſequence of theſe diſcoveries, the ſeveral ſubſtances now enumerated were claimed by the crown in moſt of the countries of Europe, and granted to ſocieties incorporated for the purpoſe of making ſaltpetre, and ſupplying the public magazines with this indiſpenſable article. England and Holland ſupplied themſelves from India and China, and therefore paid little attention for a ſhort time to this kind of manufacture: whereas France, Germany, and the Northern ſtates of Europe, encouraged it to the utmoſt of their power. At Paris theſe aſſociations or companies were incorporated ſo long ago as the reign of Charles IX.; and regulated by ſeveral ſtatutes. Their privileges were very extenſive, and enforced with ſuch rigour, that they became occaſions of diſcouraging agriculture, and of promoting tyranny and oppreſſion. They were allowed to appropriate to themſelves all the nitrous ſoils and materials which they could find, without any adequate compenſation to the proprietors. Accordingly the earthen floors of every out-houſe, and even of inhabited cottages, were ſubjected to their depredations, ſo that the people were thus deprived of their beſt manure; and moreover, every pariſh or diſtrict was under an obligation of furniſhing a certain quantity of wood-aſhes. Theſe oppreſſive powers were entruſted by the crown with the farmers-general, whoſe inferior agents exerciſed them to their own pecuniary emolument, and to the grievous annoyance of ſuch perſons as were the ſubjects of their extortion. Neverthelefs, the annual produce of nitre at the acceſſion of Turgot to the miniſtry, is ſaid to have ſcarcely exceeded one-half of its amount about half a century before his time. This able miniſter introduced a very uſeful reform in this department, reſtricted ſome of the powers which had been ſo much abuſed, and aboliſhed others; and transferred the adminiſtration of this buſineſs from the farmers-general to a particular commiſſion, of which Lavoiſier and Clouet were leading members; and a conſiderable ſum of money was placed at the diſpoſal of the Royal Academy of Sciences, to be diſtributed as prizes by this body to the authors of the beſt memoirs in the preparation of ſaltpetre; and thus important and beneficial improvements were introduced in the conſtruction and management of artificial nitre-beds, and the refining of their produce. By theſe means, the amount of nitre made in France was increaſed during the interval elapſed from the year 1775 to 1785, from 1,800,000lbs. to 3,500,000lbs. After the commencement and during the progreſs of the Revolution-war, the neceſſities of the ſtate occaſioned a great additional demand for this article; ſo that the ableſt chemiſts of Paris directed their ingenuity and ſedulous attention to this object, and their ſucceſs was ſuch, that the produce of nitre was more than quadrupled, and the art of preparing it attained nearly to perfection. From proceſſes detailed under the articles NITRIC and NITROUS *Acid*, &c. it appears, that three conditions are requiſite for the production of nitrated lime, which, by the ſubſequent addition of carbonated potaſh, affords nitre, *viz.* animal matter in a ſtate of decompoſition, atmoſpheric air, or rather the oxygenous part of it, and carbonated lime.

In Virginia, they prepare the floors of their tobacco-houſes for attracting nitre: the method of making it in this way, by Mr. Jeremiah Brown, has been publiſhed in Virginia, by order of the truſtees for the improvement of arts and manufactures, and, in England, by order of the Society for the Encouragement of Arts, Manufactures, and Commerce. See an account of this method in the Annual Regiſter for 1763, vol. vi. p. 121.

The conſtruction of artificial nitre-beds was firſt propoſed by Glauber. Having turned his attention to ſeveral previous circumſtances, he ſuggeſted the following plan for the formation of nitre, which we ſhall extract from Aikin's Dictionary.

"Let a large ſquare wooden vat be made open at top, and with a perforated falſe bottom placed a few inches above the real bottom, and between the two bottoms let a pipe with a ſtop-cock be inſerted, ſo as to diſcharge any liquor into a ſhallow open reſervoir ſunk into the ground juſt in the front of the vat: on the oppoſite ſide of the reſervoir let another vat, ſimilar to that already deſcribed, be placed, and, to complete the apparatus, let a pump be fixed in the reſervoir, by which its contents may be transferred to either of the vats that the workman chooſes. Every thing being complete, let the vats be filled with horſes', cows', or ſheep's dung, mixed with leaves or any dry vegetables: then draw a weak alkaline ley from quicklime and wood-aſhes, and pour it into one of the vats till it ſtands a finger's breadth above the other ingredients. In about 12 hours' time turn the cock, and let the liquor drain into the reſervoir, whence it is to be pumped again into the other vat, and after 12 hours more returned into the reſervoir. In the ſpace of a few days, the contents of the vats will heat and ferment ſtrongly: no further care is required till the decline of the fermentation, which may be known by the ceſſation of the ſteam: the materials are then to be again drenched with the liquor in the reſervoir for 12 hours, and when this is again diſcharged the fermentation will recommence. This method being purſued for ten or twelve months, (taking care to keep the vats filled with freſh portions of leaves and dung as the maſs ſubſides,) both the liquor and the contents of the vats will be found to be very rich in nitre."

"The above method of Glauber's," ſays Mr. Aikin, "deſerves notice as the firſt attempt at the artificial manufacture of nitre, although there is little doubt that its ſucceſs is greatly exaggerated, as is but too much the cuſtom of this author. Another method propoſed by the ſame chemiſt, and the ſucceſs of which is better authenticated, is the following. Conſtruct a vault of frame-work of any dimenſions, and line it to the thickneſs of three or four inches with plaiſter compoſed of the following materials, *viz.* one part of quicklime, one of wood-aſhes, and two of cows' or horſes' dung, with a ſufficient quantity of urine to work it up to a proper conſiſtence. This plaiſter being carefully applied, is to be dried by a gentle fire to be made under the vault, a ſecond coating of the ſame materials is then to be put on, and thus, by alternate drying and plaiſtering, the vault is to be made two or three feet thick. Being now ſufficiently ſtrong, the wooden framing may be removed. The plaiſter, in proportion as it dries, is to be reſtored to a proper ſtate of moiſture by the application of urine, and in the ſpace of a few months, more or leſs according to the warmth of the air and other circumſtances, the whole inſide of the vault will be covered with nitrous effloreſcences: by degrees the plaiſter will be impregnated with nitre through its whole ſubſtance, at which time the vault being broken down, and its materials being duly lixiviated, a large quantity of nitre will be obtained.

This method was adopted in many parts of Germany with reafonable fuccefs, but, requiring much manual labour, was at length abandoned for more economical proceffes.

" In France the nitre-beds are compofed of nitrous earth from farm-yards, ftables, &c. ; of ftreet-fweepings, of mild calcareous earth, fuch as old mortar or plaifter, chalk, tufa, or the fweepings of roads paved with lime-ftone ; of animal matter, fuch as night-foil, blood, refufe from the fkinners and tanners, bones and other offal ; of vegetable matter, fuch as ftraw and ftable litter, leaves, faw-duft, fpent tanners' bark, &c. Thefe are all mixed in fomewhat cafual proportions, care being only taken that a fufficient quantity of calcareous matter is prefent ; they are laid as lightly as poffible in long beds or pyramids under covered roofs to protect them from the weather, and are kept duly moiftened with putrid water or urine : by this management they yield every other year, by lixiviation, a confiderable quantity of nitrated lime, which, by the addition of wood-afhes or potafh, is converted into true nitre. The circumftance in which the French nitre-beds differ principally from thofe of Sweden and Germany is, that they fcarcely ever contain wood-afhes, the requifite portion of alkali being added in a fubfequent part of the manufacture.

" The proportion of nitre afforded by thefe artificial beds it is not eafy to afcertain. In France, where the cuftom is to lixiviate once in two years, the produce may be eftimated at from feven to twelve ounces of nitre from 100lbs. of materials : of this about half is nitrate of potafh, and the reft nitrate of lime, requiring therefore the addition of potafh to convert it into true nitre."

For the theory of nitrification, and particularly that of M. Thouvenel, we refer to the work now cited. Various methods have been practifed for the extraction of nitre from the earths that contain it, and the purification of this falt.

The marley earth, frequent in China, Perfia, and many parts of the Eaft, is felected for working from places where it ftands in barren cliffs, on hills facing the northern or eaftern winds. The manner of their feparating nitre from this earth is as follows : they dig large pits, which they coat over on the infide with a ftiff and firm clay ; this they fill half full of water, and into it throw the earth. When the water has ftood fome days to imbibe the falt, they draw it off into other pits, defended by flight walls on all but the north-eaft fide. Here the fun exhaling the water, the falt which it had imbibed affixes itfelf to the fides of the pit in fmall, brownifh, white, hexahedral, but very imperfect, cryftals, which are what we receive from the Eaft Indies under the name of rough nitre.

This is the way the greateft quantity of this falt is made ; but it is alfo procured from divers other materials, and by many other methods.

The method of manufacturing faltpetre in Podolia, related by Dr. Wolf, is as follows : the earth or mould, which they make ufe of for this purpofe, is of a deep black ; and they make choice of a place for their operation not far from a fpot rich enough in nitre to keep them conftantly at work, at leaft during a whole fummer, and fuch as can fupply them with water and wood at an eafy expence. The utenfils ufed in this manufacture, are a large copper boiler, containing about fixty amphors of fix gallons, or about 54lbs. of water each, which is fixed in the ground, with its brim level with the furface ; 100 wooden tubs, with a hole bored near the bottom, each of which holds a car of earth, or about four or five amphors ; two very large cafks of about 100 amphors each ; about thirty-two wide troughs or coolers, holding about an amphor each ; and a fufficient number of amphors for fetching water.

In the manufacture, the firft operation is to beat the nitrous earth to a coarfe powder with iron fpades, and to clear it of all hard fubftances. If it be very rich in nitre (indicated either by its fatnefs or its downy efflorefcence), they mix with it fome of a poorer fort, in equal quantity, but very black and old : and, laftly, they add afhes, commonly thofe of the afh, which moft abounds, to the amount of about a fifth part of the whole, and mix them well together. If they have a quantity of urine at hand, they throw it in, but never any quicklime : they then put one car of the prepared nitrous earth into one of the tubs, fill up the veffel with cold water, and ftir the whole well with a wooden ftaff ; and after it has ftood twenty-four hours, with occafional ftirring, they fuffer the ley to run out at the hole near the bottom, and put it into large cafks. In this decoction of the nitre, what they call the *mother of nitre* is abfolutely neceffary. This is the infpiffated lixivium remaining after the cryftallization of nitre, which cannot itfelf be made to cryftallize, and they keep it from one year to another. Of this mother of nitre, they pour one or two tubs into the boiler, to which they add the new ley, collected in the great cafks, till the boiler is full, and keep the contents boiling near twenty-four hours. As foon as they perceive any marks of cryftallization on the furface, they remove the ley, thus decocted and infpiffated, into the thirty-two wooden coolers, and let it remain there twenty-four hours ; in which time the cryftallization being completed, they drain off the mother of nitre, and return it into the boiler. The cryftals are taken out and dried ; but as they never prove clean, they are again diffolved in clean water, filtered through a flannel bag, and boiled up again, in a lefs boiler, to a requifite thicknefs, and then cryftallized again, which brings them to be fit for fale. In this manner, the procefs is repeated through the fummer, till the winter's froft puts a ftop to it.

The method formerly ufed in a confiderable manufacture at Paris was as follows : M. Bouret, who makes every year from 35,000 to 36,000lbs., employs fix men night and day, two rooms, twenty large cafks, and three horfes. The cafks are half filled with old plaifter, which is changed every time of pouring on water, and the lower half with wood-afhes, which are changed but once in five lixiviations. The water poured on foaks through both the plaifter and afhes, and is five times paffed through frefh plaifter. It is then boiled down in a copper pan, fo placed that the flame paffes quite round its fides. The fire is made of wood. The lixivium, when properly evaporated, is fet to cryftallize, and the cryftals to drain. The fcum taken off in the boiling is thrown upon the plaifter, which, the longer it lies in heaps, (wetted from time to time,) becomes the ftronger ; and likewife in proportion to the putrid matter thrown upon it. The plaifter ufed in the buildings at Paris, is made of that gypfeous earth called plaifter of Paris, and found in the neighbourhood of that city. In general, no lime is mixed with it ; and if this be the cafe, the nitre is neither fo good, nor produced in fo great a quantity. It is known when the old plaifter is worth being collected and employed, by the faltifh tafte of it.

The firft thing, in the procefs of extracting and purifying nitre, is to affay the earth. This is done by lixiviating a few pounds of it, and adding to the liquor thus obtained as much of a folution of common potafh, of a known ftrength, as is fufficient to decompofe all the earthy falts. From this affay, the quantity of alkali required is eafily calculated.

The next procefs is the lixiviation ; which is performed in the following manner. Several cart-loads of nitrous

earth are mixed as accurately as poſſible with the requiſite quantity of alkali, either in the form of wood-aſhes, or pulverized potaſh. Several large caſks with perforated falſe bottoms are then filled with the prepared earth laid on very lightly; after which as much river-water is poured in as the veſſels will hold. In two or three hours time the cock at the bottom of each caſk is turned, and the liquor is allowed to drain out during the remainder of the day. The caſks of a ſecond ſeries, charged with earth as before, are now filled up with the firſt lixivium, and after ſtanding for a few hours, the liquor thus concentrated is drawn off in the manner juſt deſcribed. By a ſimilar proceſs on the third day a lixivium, thrice as ſtrong as the firſt, is obtained, which is now ſufficiently concentrated to be boiled down. The contents of each ſeries of caſks are lixiviated twice more, and the weak ſolutions thus obtained are employed inſtead of water in the firſt and ſecond lixiviations of freſh parcels of earth.

The boiling down and evaporation next ſucceed. The lixivium, containing nitrate of potaſh, the muriates of potaſh and ſoda, with probably a few other ſalts, and various earthy and other impurities, is put into a large boiler like a ſalt-pan, and heated nearly to ebullition; it is then clarified by the addition of bullock's blood, or a ſolution of glue, the impurities, as they appear on the ſurface, being carefully ſkimmed off: when no more froth riſes of itſelf, a little lime-water is added, which coagulates the remainder of the blood and glue, and thus completes the clarification. It is now boiled for ſeveral hours, and the muriates of potaſh and ſoda, as they depoſit, are withdrawn by a perforated ladle. When the liquor is ſo concentrated that a few drops cryſtallize readily on being dropped on a cold iron, it is laded out into a vat, where it remains half an hour to depoſit the common ſalt and impurities ſtill floating in it: hence it is transferred to large wooden or metallic cryſtallizing baſons, where it remains cloſe covered up during from three to ſix days, according to the temperature of the air; at the expiration of this period the fluid mother-water is poured out and returned to the nitre-bed, and the ſalt depoſited in a confuſed cryſtalline maſs of an opaque dirty white, is broken to pieces and ſet to drain, after which it is brought to market, or delivered in to the government-ſtores, as rough nitre, or nitre of the firſt boiling.

In order to refine the rough nitre, the ancient practice was to ſubject it to two more ſucceſſive boilings and cryſtallizations; by this method, however, a very conſiderable proportion of the nitre was left in the mother-waters, no inconſiderable ſhare was volatilized by the heat required for evaporating the ſolution when it had nearly acquired the due degree of concentration; and beſides, a great expence both of time and fuel was incurred. The modern method of refining this ſalt was invented in France a few years ago, and is now conſidered as brought nearly to perfection. It is thus effected:

The rough nitre is broken to ſmall fragments by wooden mallets, and is then put into a wooden tub, with 20 *per cent.*, by weight, of cold water; in this ſtate it remains for ſix or ſeven hours, being occaſionally well ſtirred up, that the water may have free acceſs to every part. The water is now let out by a hole at the bottom of the veſſel, and carries with it in ſolution all the deliqueſcent ſalts, and the greateſt part of the muriates of ſoda and potaſh, together with ſome nitre. When the whole of the liquor is drained off, 10 *per cent.* more of water is added, and well mixed with the nitre for an hour's time, when it is diſcharged in the ſame manner as the firſt. Laſtly, 5 *per cent.* of water is poured in, and run off again almoſt immediately after. The nitre thus waſhed, after being well drained, is put into a boiler with half its weight of water, and boiled till a pellicle forms on its ſurface; the liquor is then diſcharged into a leaden cooler, and ſtirred about with rakes, till it is quite cold, by which manipulation the ſalt is depoſited in ſmall cryſtalline needles. It is now taken out of the liquor with a perforated ladle and well drained: after which it is waſhed with 5 *per cent.* of cold water, and again drained: being then ſpread out on a large table it dries in a few hours, and is laſtly heated over a fire in large baſons for two or three hours, at a temperature not exceeding 120° Fahr. taking care to ſtir it all the while; by this treatment it is perfectly purified, and brought to the conſiſtence of fine ſand, and is now ready to be manufactured into gunpowder. See Aikin's Dictionary.

The uſe of nitre is very extenſive in medicine, in the arts, and in chemiſtry.

Dr. Shaw, on this occaſion, obſerves, that if the medicinal virtues of nitre were to be enumerated, as they ſtand confirmed by ſufficient experience, perhaps they would prove more numerous than thoſe of any one known medicine beſides. It is ſerviceable in the ſtone and ſtoppages of urine, in deliriums, malignant fevers, diarrhœas, the ſmall-pox of the confluent kind, &c. ſo as to prove almoſt a general remedy. And all theſe excellent qualities are in this ſalt joined to that deſirable property of being innocent, or ſcarcely any way prejudicial to the body. The uſual doſe of nitre, among us, is from two or three grains to a ſcruple; though, in many caſes, it may be given with ſafety, and to better advantage, in larger quantities. From ſome experiments on the effects of nitre taken internally, related in Mr. Alexander's Experimental Eſſays, it appears, that nitre has a power of almoſt inſtantly retarding the velocity of the circulation of the blood, and of ſurpriſingly diminiſhing the number of arterial pulſations; and that its effects are much more powerful when newly diſſolved in water, than when it has remained diſſolved during ſome hours. As this difference muſt have proceeded from the cold which is produced by nitre during its ſolution, probably a much greater effect would be produced by procuring that ſolution in the ſtomach. For the various medicinal preparations of nitre, ſee Nitre, and the references under that article.

In chemiſtry, beſides the nitrous acid obtained from nitre, which is one of its moſt powerful agents, nitre itſelf is alſo uſed in many chemical operations. And in the arts, its properties of detonating with bodies containing phlogiſton, of accelerating their calcination, and eſpecially the calcination of the imperfect metals, render it uſeful for the purification of gold and ſilver, when they are allayed with other metals. As nitre is quickly and eaſily alkaliſed, it enters into the compoſition of reducing fluxes, or of ſimple fluxes, to aſſiſt fuſion and vitrification. It may alſo be employed by its detonation, to diſcover the preſence of the inflammable principle in ſubſtances. But the moſt conſiderable uſe of nitre is for the preparation of gunpowder. See Nitre, Nitrum, Nitrate, and *Nitrate of Potaſh*, under Potash.

Salts

SALTS, in *Chemiſtry*, a term formerly uſed to ſignify all ſapid ſubſtances which were ſoluble in water. The acids were termed *acid ſalts*, *alkalies*, *alkaline ſalts* ; and thoſe ſapid bodies not poſſeſſing either of thoſe qualities, *neutral ſalts*. In the preſent ſtate of chemical ſcience, the term ſalt is confined ſolely to the compounds formed by acids with the alkalies, earths, and metallic oxyds ; the

substance combining with the acid being called the base of the salt.

Neutral salts are those in which the ingredients are in exact saturation. (See NEUTRAL *Salts*, and NEUTRALIZATION.) And they are thus distinguished from those, strictly so called, that are formed by the combination of acids with alkalies, in which the properties of the one or the other predominate. When the acid predominates, the salt is designated by the syllables *super* being added to the appellation of the neutral salt, formed with the same acid and alkali; but when the alkali is redundant, the syllable *sub* is added: thus, carbonate of potash, with a redundance of acid, is supercarbonate of potash; and with a deficiency of acid, subcarbonate of potash; and as there are two varieties of acids formed from the combination of the same base or bases with different proportions of oxygen, so it has been found also necessary to distinguish the salts formed with them by different terminations; thus the salt composed of *sulphuric* acid and potash is termed *sulphate* of potash, while that formed with *sulphurous* acid and the same alkaline base, is termed *sulphite* of potash. When the acid has the term *oxy* prefixed to its name, the same syllables are prefixed to that of the salt: thus, *oxymuriate of potash* denotes a salt composed of the oxymuriatic acid and potash.

The neutral and other secondary salts have very different degrees of solubility; but that of almost all of them is increased by an augmented temperature, while their solution is for the most part accompanied with a diminution of temperature. They may be obtained unaltered from solutions by evaporation; and, if the process be slowly conducted, they form in regular crystallized masses, which have more or less transparency according to the quantity of water which they retain in their composition. Exposure to air, heat, and moisture, variously affect the appearance of crystallized salts. When they lose their transparency, and are covered with a white crust, or fall to powder, on simple exposure to the air, such salts are said to be *efflorescent*; if, on the contrary, they attract moisture from the atmosphere and become fluid, they are named *deliquescent*; and *permanent*, when the air has no effect on their crystals. The circumstance of a salt first melting in a moderate heat, then becoming covered with a white crust, and ultimately being converted into a dry opaque mass, is termed *watery fusion*; but when, instead of melting, it splits with a crackling noise, this effect is termed *decrepitation*.

The efflorescent and deliquescent salts should be preserved, and dispensed in well-stopped bottles; while those that are permanent will not suffer from being put up in paper.

The following abstract of Mr. Kirwan's table of the composition of salts, shews at one view the quantity of base, acid, and water contained in the salts medicinally used.

Names of the Salts.	Base.	Acid.	Wate	State
Carbonate of potash - -	41.	43.	16.	Crystallized.
——— of soda - -	21.58	14.42	64.	Dry.
——— of ditto - -	59.86	40.05		Desiccated.
——— of lime - -	55.	45.		Natural.
——— of magnesia - -	25.	50.	25.	Crystallized.
———, common magnesia -	45.	34.	21.	Dried at 80°.
Sulphate of potash - -	54.8	45.2	—	Dry.
——— of soda - -	18.48	23.52	58.	Fully crystallized.
——— of ditto - -	44.	56.	—	Desiccated at 700°.
——— of magnesia - -	17.	29.35	53.65	Fully crystallized.
——— of ditto - -	36.68	63.32	—	Desiccated.
Alum - - - -	12.*	17.66	51.†	Crystallized.
Ditto - - - -	63.75	36.25	—	Desiccated at 700°.
Nitrate of potash - -	51.8	44.	4.2‡	Dried at 70°.
Muriate of soda - - -	53.	47.§		Dried at 80°.
——— of ammonia - -	25.	42.75	32.25	Sublimed.
——— of barytes - -	64.	20.	16.	Crystallized.
——— of ditto - -	76.2	23.8		Desiccated.
——— of lime - -	50.	42.		Red-hot.
——— of magnesia - -	31.07	34.59	34.34	Sensibly dry.
Acetate of potash - -	61.05	38.05		In foliated mass.‖

* Ignited. † Of crystallization + 19.24 in the base.
‡ Of composition. § Aqueous 38.88 real. ‖ Higgins.

See NOMENCLATURE, and the different bases of salts under which the salts are described.

The general plan of this work has been to treat of the salts, as understood by the last definition, under their respective bases. We find, however, that this plan has been deviated from in the articles ALUMINA, BARYTES, and POTASH. This being the case, we think this the most proper place in which to supply the deficiency, and refer to the respective bases for the rest.

Sulphate of Potash.—This salt has been called in medicine *sal polychrest*, and in the old chemical nomenclature, *vitriolated tartar*. It is formed by directly adding sulphuric acid to a solution of potash, till the mixture is neither acid nor alkaline, which will be the case when it does not change the colour of infusion, or syrup of violets. This mixture on evaporation affords crystals, which are larger and more complete as the time in which the water is escaping. These crystals are in the form of short six-sided prisms, terminating in pyramids of the same number of sides.

The specific gravity of this salt, in its perfect state, is about 2.4. It does not possess much taste, which is rather bitter. It dissolves in sixteen parts of water at 60°, and in four parts of water at 212°. It is not changed by exposure to the air. When thrown upon burning coals it decrepitates, like common salt. Exposed to a strong heat in a crucible it melts. If charcoal, or, which is better, saw-dust, be present, it is speedily converted into a sulphuret of potash, called also *liver of sulphur*. Its composition by Dr. Wollas-

ton's ſcale is in 100 parts, 46 ſulphuric acid, and 54 potaſh. By Dalton's numbers 45 acid, and 55 potaſh. Theſe proportions agree very nearly with the analyſes of Bergman, Kirwan, Wenzel, and Dr. Thomſon. The latter makes it 42.2 acid, 50.1 potaſh, and 7.7 water. It would ſeem from the latter that this ſalt conſiſts of an atom each of acid, baſe, and water. This would be in Dalton's numbers 34 acid, 42 potaſh, and 8 water, which is doubtleſs near the truth.

This ſalt is partially decompoſed by the nitric and muriatic acids; and its ſolution is completely decompoſed by muriate of barytes, muriate of lime, lime-water, oxymuriate of mercury, nitrate of ſilver, and acetate and ſuperacetate of lead, which therefore cannot enter into formulæ with it. In medicine, it is deobſtruent and cathartic. It is given with great advantage in the viſceral obſtructions to which children are liable, and in combination with rhubarb it has been found more uſeful than any of the other ſaline purgatives in jaundice and dyſpeptic affections. It is generally given in the form of powder, in doſes of from x gr. to ℥vi, as it is intended to act as a deobſtruent or a purgative. Its officinal preparations are, "Pulvis ipecacuanhæ compoſitus," L. E. D.; and "Pulvis ſcammoniæ compoſitus," L. See Powder.

Sulphate of potaſh with *ſulphur*, formerly "Polychreſt ſalt," is directed by the Edinb. Pharm. to be prepared by mixing well together, equal parts of nitrate of potaſh in powder, and ſublimed ſulphur, and throwing the mixture in ſmall quantities at a time into a red-hot crucible. When the deflagration terminates, let the ſalt cool, and preſerve it in a well-ſtopped glaſs veſſel. This ſalt has a ſenſibly acid taſte, and reddens infuſion of litmus: it is almoſt wholly diſſolved in eight parts of water at 60°; and by expoſure to the air, it is altogether converted into ſulphate of potaſh. Its medical properties and uſes are the ſame with thoſe of ſulphate of potaſh; but it is very rarely uſed.

Superſulphate of potaſh, or, agreeably to a more modern nomenclature, *biſulphate of potaſh*. Its name indicates that it contains two atoms of acid to one of potaſh. It is formed by heating a ſolution of 84 parts of potaſh and 42 of ſulphuric acid, of the ſpecific gravity of 1.85. It cryſtallizes into long ſix-ſided priſms, having the appearance of needles. Its taſte is ſharp and acrid. It diſſolves in about three (five Thomſon) parts of cold water at 60°, and in its own weight of boiling water. It is not changed by expoſure to the air. When heated in a platina crucible it fuſes into a tranſparent fluid, but becomes white and hard on cooling.

The compoſition of this ſalt, as well by an experiment made by Dr. Wollaſton, as by theory, will be 34 × 2 acid, 42 potaſh, and probably 16 of water. Its efficacy as a remedy is yet unknown.

Nitrate of Potaſh. See Potassæ *Nitras*.

It is the rapid evolution of the elaſtic fluids, reſulting from the decompoſition of the nitric acid, by the agency of the inflammable matter, that conſtitutes the energy of gunpowder, and the report of the pulvis fulminans, for the manufacture of which, ſee Gunpowder, and Fulminans *Pulvis*.

The very extenſive conſumption of nitrate of potaſh in the manufacture of gunpowder, has made it a deſideratum in ſome countries to obtain it by ſome artificial means. The great ſupplies of nitre have been from thoſe warm countries where it exiſts native in the common ſoil. It abounds in this ſtate in Egypt, India, South America, and Spain. Some parts of the ſoil contain much more than others. Where it is found plentifully the earth is collected into immenſe piles and lixiviated, which diſſolves the nitre, and any other ſoluble matter. This liquor is evaporated and the nitre obtained in cryſtals. The firſt cryſtallization is always impure, and is called *crude nitre*. The pure nitre can only be obtained by repeated ſolutions and cryſtallizations. It has been the opinion of ſome philoſophers that nitre has its origin in vegetables, becauſe it is often found an ingredient in their analyſis. Several parts, however, both in natural and artificial nitre-beds, go far to prove that it originates in the earths themſelves, aided by the preſence of atmoſpheric air, by the heat and perhaps the light of the ſun.

The author of this article has been informed by a friend recently travelling in Spain during the laſt ſeaſon, that in many parts of that country he found it difficult, and frequently impoſſible, to get a draught of water that was not impregnated with nitre, and in ſome places he found nitre in the ſoil. In the neighbourhood of Madrid, immenſe heaps of this ſoil were collected for the purpoſe of extracting the nitre from it. What, however, is the moſt remarkable, and which tends to confirm the opinion above given reſpecting its origin, is, that theſe heaps, in a few years after having been lixiviated, which muſt have removed all the ſoluble parts, became again capable of furniſhing a ſimilar quantity of nitre; and what ſtill more confirms the above idea, this proceſs had been repeated upon the ſame heap ſeveral ſucceſſive times. It appears from this fact, that ſome ſorts of ſoil are capable of furniſhing nitre by merely being expoſed to air in warm climates.

This ſalt has been formed in great abundance in France and Germany, by what are called artificial nitre-beds. Theſe conſiſt of long narrow heaps of a collection of animal and vegetable matter, mixed with calcareous and other earths. Sheds are thrown over theſe heaps to ſhelter them from the rain, and keep up their heat; and they are alſo kept at a certain degree of moiſture, by occaſionally throwing water upon them. This keeps up to a certain extent the putrefactive fermentation in the animal and vegetable ſubſtances. The heat which theſe generate may contribute much to the proceſs, as well as furniſhing potaſh for the nitre. It is ſuppoſed that the nitrogen afforded by the animal matter in its naſcent form may be more fitted for forming nitric acid with the oxygen of the atmoſphere than is the nitrogen of the atmoſphere, which is only preſented in its gaſeous form. There is, however, no proof of this being the caſe, ſince we find nitre produced where no animal or vegetable ſubſtance is preſent. Theſe beds afford nitre after being expoſed a certain length of time. The heaps are ſometimes turned over, which facilitates the production of nitre. The nitre, mixed with other ſalts, effloreſces on the ſurface of the heaps, and is ſwept with brooms from time to time. Theſe ſweepings are collected and purified by lixiviation and cryſtallization.

The earth itſelf is alſo lixiviated at certain periods, and then re-expoſed. In Switzerland theſe nitre-beds are frequently connected with ſtables on a large ſcale, to take advantage of animal excrement.

Many vegetables furniſh nitre in conſiderable quantity, particularly thoſe that are poiſonous, or poſſeſſing much odour. The extracts made from hemlock, henbane, and quaſſia, in a length of time become covered with cryſtals of nitre. During the maceration of henbane in hot water, for the purpoſe of making the extract, the nitric acid of the nitre is to a certain extent decompoſed; as nitrous gas may be collected in conſiderable quantities. Is it not probable that thoſe plants which furniſh more than an ordinary quantity of potaſh, ſuch as wormwood and the ferns, may originally contain nitre, which is decompoſed during their incineration, leaving the potaſh combined with carbonic acid?

Nitre is ſometimes uſed in preſerving meat, particularly hams. It is to the effect of this ſalt that the meat owes its

red colour. This colour is produced by the presence of the oxygen, or at least by the abstraction of carbon, precisely on the same principle that venous blood becomes red. The fresh cut muscle, which is of the colour of venous blood, soon becomes changed by similar exposure to the air, and also by the application of nitre. What corroborates this idea is the fact, that when too much nitre has been used upon meat, it acquires the exact flavour of nitrous gas, and the parts most susceptible of this smell exhibit the prismatic colours. See SALTPETRE.

Muriate of Potash.—This salt was, before the present nomenclature, called *regenerated sea-salt;* and in medicine it was called *digestive salt of Sylvius.* See POTASSIUM.

It is best formed by adding muriatic acid to the crystallized carbonate of potash, till the effervescence ceases. This solution, by slow evaporation, affords cubic crystals, which are the salt in a state of purity.

Its taste is bitter. The specific gravity of the perfect crystals is 1.836. It dissolves in three times its weight of water at 60°, and in a little less than two parts at 212°. It is slightly deliquescent in the air. When exposed to heat, like the muriate of soda, it decrepitates. At a red heat it melts, and at an increased temperature it sublimes in white fumes.

This salt, in the dry state, is considered by sir Humphrey Davy as a compound of chlorine and potassium; in its humid state, it is a compound of potash and muriatic acid. When in this last state heat is applied, the oxygen of the potash combines with the hydrogen of the muriatic acid, forming water, which is driven off, leaving what sir Humphrey has turned *potassane*, and what Dr. Thomson has called *chloride of potassium*, and what in the old language would be termed *muriate of potash.* This salt, in the dry state, according to Wenzel, is composed of 35 acid and 65 potash; and, from the authority of Rose, 34 acid and 66 potash. By Dr. Wollaston's scale, it is 36.5 acid and 63.5 potash. By Dalton's numbers, 22 acid and 42 base; or, in the 100, it is 34.5 acid and 65.5 potash. These accounts so nearly agree, as to leave little doubt of their accuracy. See MURIATIC *Acid.*

Hyperoxymuriate of Potash.—This salt was first discovered by Dr. Higgins, but Berthollet was the first who pointed out its constitution and particular properties. It has since been examined by Lavoisier, Van Mons, Fourcroy, Vauquelin, Hoyle, Chenevix, and others. The latter chemist has given a very able paper upon this class of salts, in the Philosophical Transactions for 1802.

This salt is prepared by passing oxymuriatic acid gas through a solution of one part potash to six parts water. For this purpose, the latter solution may be put into the bottle B. (See *Plate* XVII. *Laboratory, fig.* 9.) The retort, A, contains the materials for producing the oxymuriatic acid. The gas, on entering the bottle B, first forces the liquid up the tube into the bottle C, and then slowly follows it in bubbles. These are generally absorbed before they reach the bottle C. If this should not be the case, the remaining gas descends by the tube *b* to the bottle D, which contains a solution of potash similar to that in B. When the alkali is nearly saturated, the salt in question begins to precipitate in the form of brilliant scales, or plates. These are not perfectly pure, but, by dissolving them in about three times their weight of boiling water, the salt falls down in greater purity as the water cools.

The form of the crystals of this salt, although they appear in the form of thin plates when minutely examined, is found to be that of the parallelepiped, or rather obtuse rhomboids.

It has a cooling, sharp, and rather acrid taste. It dissolves in 17 or 18 parts of water at 60°, and in $2\frac{1}{2}$ parts of water at 212°. It is not changed by exposure to the air. When exposed to heat, it first undergoes the aqueous fusion. If the heat be increased, the salt is at length decomposed. A large quantity of oxygen gas escapes, equal to one-third of the weight of the salt, leaving behind two-thirds of muriate of potash.

Its action upon combustible bodies constitutes its most remarkable properties. When three parts of this salt and one of sulphur are smartly rubbed in a mortar, a succession of explosions take place, not unlike the cracks of a whip. These are attended with flashes of purplish light, and a smell of sulphureous acid. The same mixture laid upon an anvil, and struck with a hammer, gives a loud report. When phosphorus is used instead of sulphur, the effects are much more violent. Similar, but less striking, phenomena are observed, when this salt is mixed with charcoal, sugar, starch, or gum, and almost any other dry vegetable matter. When these mixtures are touched with concentrated sulphuric acid, inflammation instantly ensues. This effect is still more conspicuous, when the mixtures are projected into the acid. In these experiments, the greatest caution should be observed. In the detonations by friction, or percussion, the eyes and hands of the operator should be guarded. The mixture with sulphur sometimes explodes spontaneously. Similar detonations also take place with metals and this salt, particularly the more oxydable metals. These energetic properties suggested the idea of using it, instead of nitre, in the manufacture of gunpowder; but its property of exploding by friction, renders even the mixture of the materials too hazardous to be practised. In the very first attempt to form the compound, two individuals lost their lives.

This salt is decomposed by nitric acid, which disengages the oxygen and the oxymuriatic acid.

The dilute muriatic acid added to this salt, in a very small retort, disengages a peculiar gas, which was discovered by sir Humphrey Davy, to which he has given the name of *euchlorine.* See OXYMURIATIC *Acid.*

We shall best shew the constituents of this salt, as well as its particular analysis, by referring to the chemical changes which take place in its formation.

According to the new hypothesis, which sir Humphrey Davy and some other chemists have adopted, the salt in question consists of 1 atom of chlorine, 1 of potassium, and 6 of oxygen. Agreeable to the common opinion, it consists of 1 atom of muriate of potash, with 6 of oxygen; or 1 of muriatic acid, 6 of oxygen, and 1 of potash.

By the first opinion, 6 atoms of chlorine enter the solution of potash: 5 of these decompose 5 atoms of water, with the hydrogen of which they form 5 atoms of muriatic acid. These combine with 5 atoms of potash, forming 5 atoms of potassane, and 5 atoms of water. The 6th atom of chlorine combines with 5 atoms of the oxygen derived from the water: these combining with an atom of potash, form an atom of the hyperoxymuriate of potash. If the atom of hydrogen be 1, oxygen 7, chlorine 29, and potassium 35; then 5 atoms of potassane will be $(29 + 35) \times 5 = 320$, and 1 atom of the hyperoxymuriate will be $29 + 35 + 42 = 106$.

By the old opinion, when 6 atoms of oxymuriatic acid enter the solution of potash, 5 of them give up their oxygen to the 6th. The first 5, which have become muriatic acid, combine with 5 atoms of potash, forming 5 atoms of muriate of potash. The 6th atom, with its 5 extra atoms of oxygen, combine with an atom of potash, forming an atom of the hyperoxymuriate. Here, oxymuriatic acid, as its name indicates, is supposed to be formed by 1 muriatic acid $= 22$, and 1 of oxygen $= 7$, being together equal to 29. The 5 atoms of muriate of potash will be $(22 + 35 + 7)$

$\times 5 = 320$; and the atom of hyperoxymuriate will be $(22 + 6 \times 7 + 35 + 7) = 106$, as before. We here see that both these theories explain the fact, and the result is the same in both, when the same elementary numbers are taken. From these data, the composition will be in a hundred parts,

Muriate of potash - -	60
Oxygen - - - - -	40
	100

In classing this among the rest of the salts, we might presume the existence of an acid called the hyperoxymuriatic acid. This, however, has not as yet been obtained in a free state. The euchlorine of sir Humphrey Davy was at one time thought to be this acid; but since the latter is constituted by 29 oxymuriatic acid and 7 oxygen, while the acid united to potash, forming the salt in question, would consist of 29 + 5 × 7, such a supposition cannot be maintained. If the old opinion keep its ground, the proper name for this salt, agreeably to what has been laid down under NOMENCLATURE, would be *hectoxymuriate of potash*. But if the new opinion prevail, it would be called, according to the nomenclature of Dr Thomson, *hectoxychloryde of potassium*.

Superphosphate of Potash.—This salt is formed by adding the liquid phosphoric acid to a solution of the crystallized carbonate of potash, till the effervescence ceases. By evaporation it assumes the form of a gelatinous mass, but does not crystallize. It has a sweetish-saline taste. When dry, its specific gravity is 2.85. It attracts humidity from the air, and is very soluble in water.

When heated, it first undergoes the watery fusion, afterwards becomes dry. The heat being raised, it melts into a transparent glass, which is deliquescent in the air. No analysis of this salt is known. By Dalton's numbers it is 46 acid and 42 potash, in 88 parts.

Phosphate of Potash.—This salt cannot be formed by directly adding the acid to the alkali, in a state of solution; as, in that case, the salt last described is always formed. In order to form the present salt, the superphosphate must be fused in a platina crucible with a quantity of alkali equal to that already contained in it. The white mass thus formed is the salt in question. The more certain way of forming this salt is to boil the alkali and the above salt together: a white powder subsides, which, being separated and dried, is the pure phosphate of potash. See MURIATIC *Acid*.

Fluate of Potash.—This salt may be formed by directly adding the liquid fluoric acid to potash, till neutrality is effected. Scheele says it does not crystallize; Wenzel, however, informs us that it does, when perfectly free from silex. It dissolves in water, and melts in a strong heat. See FLUORIC *Acid*.

Borate of Potash.—This salt may be formed by heating together nitre and borax (borate of soda). The nitric acid is driven off, and the potash decomposes the borax. By solution in water, and slow evaporation, the salt is obtained in crystals. According to the analysis of Wenzel, it is composed of 100 acid and 30 of potash. See BORACIC *Acid*, and BORAX.

Carbonate of Potash, or *Pure Subcarbonate of Potash* of the Edinb. Pharmacopeia.—This salt is called salt of tartar, from having been formed by the calcination of tartar. When pure potash is exposed to the air, it soon attracts water sufficient to liquefy it, and also carbonic acid, ultimately becoming a solution of carbonate of potash. By evaporation it affords crystals, which require to be kept from the air to prevent their deliquescence. This salt may also be formed by deflagrating nitre with supertartrate of potash.

The composition of this salt has been very clearly made out by several able chemists. By Dr. Wollaston's scale, it is composed of 68 potash and 32 carbonic acid, in the dry state. By Dalton's numbers, of 19.4 acid and 42 potash; which in the 100 is 68.3 potash and 31.7 carbonic acid. See CARBONATE *of Potash*.

Subcarbonate of Potash. See POTASSÆ *Carbonas*.

Supercarbonate or *Bicarbonate of Potash*.—This salt differs from the last in containing twice as much carbonic acid. It is formed by adding carbonate of ammonia to the carbonate of potash, the salt last described, and distilling off the ammonia. The solution, by evaporation to a certain extent, and by slow cooling, affords crystals, appearing in plates lying one over the edge of the other. The most advantageous way of forming this salt is by passing carbonic acid gas through a strong solution of salt of tartar (carbonate of potash), in the apparatus, *Plate* XVII. *fig.* 9. (See LABORATORY.) The salt crystallizes without evaporation, the crystals being very large and well-formed.

This salt has a cooling taste, not the least caustic, nor scarcely alkaline. It dissolves in about four parts of water at 60°. When dissolved in boiling water, it seems to undergo a partial decomposition, as bubbles of carbonic acid escape: hence it should not only be formed in cold water, but dissolved in it, when used.

When this salt is heated to redness, it is completely converted into the carbonate of potash, having lost just half of its acid. From this fact, which has been mentioned by Dr. Wollaston, its composition will be obvious; being 68 potash to 64 carbonic acid, and *per cent.* 47 carbonic acid and 53 potash. From Dr. Wollaston's scale, it appears to consist of 2 atoms of acid, 1 of potash, and 1 of water. This will give *per cent.* 43 carbonic acid, 47.9 potash, and 9.1 water of crystallization.

Arseniate of Potash.—This salt is formed by adding arsenic acid to potash.

It does not crystallize. If exposed to the air in a dry state, it deliquesces.

When fused with a strong heat, it forms a white glass. If inflammable matter be present, the salt is decomposed by the metal losing its oxygen. The arsenic sublimes at the same time.

Superarseniate of Potash.—This salt, from its name, contains an excess of acid, probably twice as much. It is formed by adding more acid to the last salt. It crystallizes in quadrangular prisms. See ARSENIC, § 10.

The molybdate and chromate of potash are but little known.

Acetate of Potash.—This salt may be formed by adding pure acetic acid to a solution of carbonate of potash, till mutual saturation takes place. It is very difficult of crystallization, but it may be effected by a very slow evaporation. It has a sharp unpleasant taste. It is soluble in about its own weight of cold water. It becomes moist by exposure to the air. Like the rest of the salts, with vegetable acid it is decomposed by a strong heat, the residuum being charcoal and potash. See ACETIC *Acid*.

The London Pharmacopeia directs it to be prepared by mixing together, in a large glass vessel, $1\frac{1}{2}$ lb. of subcarbonate of potash and a gallon of (diluted) acetic acid; and having evaporated the solution to one-half over the fire, by adding gradually as much more (diluted) acetic acid as may be necessary for perfect saturation. Let the solution be again evaporated to one-half, and strained; then continue the evaporation in a water-bath, so that, on being removed from the fire, crystals shall form.

Acetite of Potash of the Edinburgh Pharmacopeia is pre-

pared by boiling one pound of pure carbonate of potash, with a very gentle heat, in four or five times its weight of distilled acetous acid, and adding more acid at different times, until, the watery part of the former portion being nearly dissipated by evaporation, the acid newly added occasions no effervescence, which will be the case after about 20 pounds of acid have been consumed; then evaporating slowly to dryness. Liquefy the remaining in pure salt with a gentle heat for a short time; then let it be dissolved in water, and filtered through paper. Afterwards evaporate this fluid, which, if the liquefaction be properly performed, will be limpid, otherwise of a brown colour, in a shallow glass vessel, with a very gentle heat; occasionally stirring the salt as it concretes, that it may the more quickly become dry. Finally, preserve the acetite of potash in closely shut vessels, to prevent its being liquefied by the air.

Acetate of Kali of the Dublin Pharmacopeia is formed by adding to any quantity of subcarbonate of kali, at different times, about five times its weight of distilled vinegar moderately heated: when the effervescence has ceased, and the fluid is somewhat evaporated, add, at intervals, more distilled vinegar, until the effervescence entirely ceases: then evaporate to dryness, and having raised the fire a little, cautiously liquefy the mass. Dissolve the salt in water after it is cold; filter the solution, and boil it, until, on being removed from the fire, it concretes into a crystalline mass, which should be very white. Put the mass immediately into close-stopped vessels.

Acetate of Potash has a slight peculiar odour, and a warm sharp taste. One fluid-ounce of distilled water at 60° dissolves 504 grains; or 100 parts of it are soluble in 105 parts of water, and in twice its weight of alcohol. In the watery solution it is spontaneously decomposed; and it is also decomposed by the strong acids, by a decoction of tamarinds, by the sulphates of magnesia and of soda, by the muriate of ammonia, the tartrate of potash and soda, and by solutions of oxymuriate of mercury, and of the nitrate of silver; which of course cannot enter into formulæ with it. See ACETIC *Acid*.

As to the medical properties and uses of this salt, it is mildly cathartic and diuretic; occasionally beneficial in febrile affections and jaundice, but principally used in dropsies, and other diseases requiring a copious discharge of urine. For producing the latter effect, the dose may be from ℈j to ʒj, given every three or four hours, in any bland fluid. Doses of ʒij or ʒiij open the bowels. Its officinal preparations are "Acetas hydrargyri," E. D.; "Tinctura acetatis ferri," D.; and "Acidum aceticum," D. Thomson's Disp.

Oxalate of Potash.—This salt is easily formed by saturating a solution of the crystals of this acid with potash; and by adding a little excess of the alkali, the salt will be capable of crystallization. The crystals are long six-sided prisms.

Superoxalate of Potash.—This is formed in the wood sorrel, and is sold under the names of *salt of sorrel*, and *salt of lemons*, and is sometimes bought for lemon acid. It may be formed artificially, by dropping a solution of potash, by a little at a time, into a saturated solution of oxalic acid. The salt to be formed is so much less soluble than the acid, that as soon as it gets the proper dose of alkali to constitute the superoxalate, it falls to the bottom of the vessel in small crystals, which, when examined minutely, are small four-sided figures.

Neither of these salts have been analysed, but their proportions may be readily calculated, since the weight of the atom of oxalic acid is well defined, being about 40 times heavier than that of hydrogen. The first salt will, therefore, be 40 of acid and 42 of potash, or *per cent.* 49 acid and 51 base. The superoxalate will be 80 acid and 42 base, or in the 100, 65.5 acid to 34.5 base. See OXALIC *Acid*, and OXALIS.

Tartrate and Tartrite of Potash. See TARTRATE and TARTRITE.

Supertartrate of Potash.—This salt exists in nature, particularly in the juice of the grape. It is generally collected from the sides of wine-casks, and may always be seen adhering to the sides of wine-bottles, when the wine has been kept for some time. This salt, when purified, is known by the names of cream of tartar and crystals of tartar. These, when well formed, are short six-sided prisms. It dissolves in 60 parts of cold water, and in half that quantity of boiling water. When exposed to heat it soon becomes black This arises from the decomposition of the acid, the potash being left in the state of carbonate, since carbonic acid is one of the results of the decomposition. A portion of the acetic acid is also formed during this decomposition, which may be collected and mixed with some empyreumatic oil. This product was called pyrotartareous acid, but is now found to be acetic acid, mixed with the empyreumatic oil.

Tartrate of Potash.—This salt is known in medicine by the name of soluble tartar, to distinguish it from the last, which so sparingly dissolves in water. It may be readily formed, by adding to the supertartrate a solution of as much potash as it already possesses. This solution, by evaporation and gradual cooling, affords crystals in the form of four-sided prisms.

Its taste is rather bitter. It is soluble in almost four parts of cold water, and in much less of boiling water. It is decomposed by heat like the last.

The composition of the supertartrate, according to Bergman, is

Tartaric acid	77
Potash -	23

Or,

Tartrate of potash	56
Acid -	44
	100

By the analysis of Thenard, it is

Acid -	57
Potash -	33
Water -	7
	97

This last is probably near the truth; the first is very far from being so. See TARTRITE.

The malat, gallat, benzoat, succinat, and saccolat of potash, are but little known.

Camphorate of Potash.—This salt is formed by adding camphoric acid to carbonate of potash, till carbonic acid ceases to be evolved. The solution on evaporation affords crystals.

This salt is soluble in four parts of boiling water, and in 100 parts at 60°. It dissolves in alcohol, which causes it to burn with a blue flame. See CAMPHOR.

The rest of the salts of potash are not known to possess remarkable properties.

Sulphate of Barytes.—This salt exists abundantly in nature under the name of ponderous earth, and *caulk*. From its insolubility in water, it cannot be formed artificially but in the state of white powder. In nature it occurs in crystals, in the form of transparent plates, or rather four-sided prisms, the bases being rhombs; the primitive form of the crystals

being the same. To all appearance, it is the most soluble salt which has occurred. Boiling water dissolves more than half its weight, but cold water dissolves only $\frac{1}{25}$th. Boiling sulphuric acid dissolves it, but it is precipitated by the addition of water. When exposed to the heat of 35° of Wedgewood, it fuses into an opaque glass or enamel. No single acid or base is capable of decomposing this salt, but the carbonates of potash and soda are said to decompose it by double decomposition. The most effectual way of separating the earth from it, is to expose it mixed with saw-dust, in a covered crucible, to a strong red heat for several hours. The sulphate is by this operation converted into a sulphuret, which is soluble in water. The sulphur may now be separated by weak nitre, or acetic acid, which dissolves the barytes. The acid may afterwards be driven off by a red heat. The analysis of Kirwan, which seems the most correct, is

Barytes	-	67
Sulphuric acid		33

Aikin makes it

Barytes	-	66.04
Acid	-	33.96
		100

Dalton's numbers give the acid 34, and the barytes 68. This reduced to 100, gives

Barytes	-	66.75
Acid	-	33.25
		100

See Barytes.

Nitrate of Barytes. See Nitrate *of Barytes*, under which article the reader is desired to correct the number expressing its specific gravity, and to substitute 2.92.

According to Kirwan, its constituents are

Acid	-	32
Barytes	-	57
Water		11

By Dalton's numbers, this salt is composed of two atoms of acid, and one of base; and from the last analysis it would seem two atoms of water. These would make $2 \times 19 + 68 + 2 \times 8 = 122$. This reduced to 100, gives

Acid	-	31.1
Base	-	56.7
Water	-	12.2

Muriate of Barytes.—This salt may be formed precisely by the same directions as the last, using the muriatic acid as the solvent. The evaporation being now carried to a certain extent, the liquid may be set aside to crystallize. These crystals will be more complete by leaving the solution, slightly covered with a piece of gauze, to spontaneous evaporation. If a few crystals of the same salt are placed in the solution as soon as the crystallization begins, they will form needles for the new crystals, which may be obtained of great size. Under some circumstances the crystals are apt to become yellow, but the cause of this colour does not appear obvious. There is another method of preparing this salt, when the carbonate of barytes cannot be procured, by first converting the sulphate, which is very abundant in the vicinity of most lead-mines, into a sulphuret, as directed in decomposing the sulphate of barytes, and adding muriatic acid to the sulphuret. This precipitates the sulphur, and forms muriate of barytes. This solution, filtered and evaporated, affords crystals of the salt. These crystals are in the form of plates, but when examined, they are four-sided prisms, with square bases.

It has a strong and disagreeable taste, and is said, like the rest of the barytic salts, to be poisonous. It is not altered by exposure to the air. It dissolves in about twice its weight of water at 60°, and is not much more soluble in hot water. Hence its crystallization is to be effected by a slow evaporation, rather than by a slow cooling. It decrepitates at the same heat that other salts do, and is not decomposable at the strongest heat. In the fused state it is considered, by the new doctrine, as a compound of chlorine and barium, which would in the 100 be 65.5 barium, and 34.5 chlorine.

In its crystalline state, Kirwan makes its composition to be

Acid	-	20
Barytes	-	64
Water	-	16

Fourcroy's analysis gives

Acid	-	22.93
Barytes		62.47
Water	-	14.6

Aikin gives

Acid	-	24
Barytes	-	60
Water	-	16
		100

Dr. Wollaston's scale gives for the dry salt

Acid	-	26
Barytes	-	74
		100

And the crystallized would be from the same

Acid	-	22.25
Base	-	63
Water	-	14.75
		100

Dalton's numbers will give 22 acid, 68 base, and 16 water, which *per cent.* is

Acid	20.75
Base	64.1
Water	15.15

This salt is used only as a chemical test for detecting the presence of sulphuric acid, and in determining the proportion in which that acid exists in different bodies. See Barytes.

The muriate of barytes is prepared, according to the directions of the Edinb. Pharm., by mixing together three parts of water, and one part of muriatic acid, and adding one part

of carbonate of barytes broken into ſmall pieces. When the efferveſcence terminates, digeſt for an hour; then filter, and after due evaporation ſet the ſolution apart, that cryſtals may be formed; and repeat the evaporation as long as any cryſtals are formed. If the carbonate of barytes cannot be procured, the muriate of barytes may be formed in the following manner:

"Take of ſulphate of barytes, two pounds; charcoal in powder, four ounces. Roaſt the ſulphate, that it may be the more eaſily reduced to a very fine powder, and mix it with the powder of charcoal. Put the mixture into a crucible, and having fitted to it a cover, let it be expoſed to a ſtrong fire for ſix hours; then, having well triturated the matter, put it into ſix pounds of boiling water, in a glaſs or earthen veſſel, and mix by agitation, preventing, as much as poſſible, the action of the air.

"Let the veſſel ſtand in a vapour-bath until the undiſſolved part ſhall have ſubſided, and then pour off the liquor. Pour on the reſidue four pounds of boiling water, which, after agitation and ſubſidence, add to the former liquor; and then, while it is ſtill hot, or, if it ſhall have cooled, after it is again heated, let muriatic acid be dropped into it as long as any efferveſcence is excited. Then let the ſolution be filtered and evaporated, that cryſtals may be formed."

Several other methods have been propoſed for the preparation of this ſalt, the beſt of which is the following, recommended by Bouillon la Grange (Annales de Chimie, xlvii. 131.) Pulverize together equal parts of ſulphate of barytes and muriate of lime; project the mixture into a red-hot crucible, and let the fire be continued till the whole be melted, which is then to be poured out on a heated tile. After it is cold, reduce the maſs to powder; boil it for ſome minutes in ſix times its weight of diſtilled water, and filter the ſolution: then evaporate the liquor to a pellicle, and ſet it aſide to cryſtallize. The cryſtals require to be re-diſſolved and again cryſtallized, to free them from any of the calcareous muriate they may retain on the firſt cryſtallization. The Edinburgh proceſs, however, is ſtill preferable to this of La Grange, as the previous calcination reduces any metallic ſalts that may be combined with the ſulphate; and being thus rendered inſoluble, they are ſeparated during the firſt ſolution of the ſulphuret. Goetling adviſes muriate of ſoda to be added to the charcoal, by which a ſmaller quantity of charcoal is capable of reducing a larger quantity of ſulphate of barytes. A mixture of one part of muriate of ſoda and two parts of muriate of lime is ſufficient to decompoſe ſix of ſulphate.

Muriate of barytes has an acrid, very nauſeous, bitter taſte. It cryſtallizes in grouped quadrangular tables, bevelled on the edges; tranſparent, white, and very brilliant; of a ſpecific gravity of 2.8257; and not alterable from expoſure to the air. When heated, it decrepitates, becomes opaque, and ultimately melts, but is not decompoſed. One part requires three of water at 60° for its ſolution, and 2.20 of hot water. According to Kirwan, the conſtituents of 100 parts of this ſalt are, 64 of barytes, 20 of muriatic acid, and 16 of water. It is uſed only for forming the following ſolution, which is directed in the Edinb. Pharm. to be prepared by diſſolving one part of the muriate of barytes in three parts of diſtilled water. This ſolution poſſeſſes all the chemical and medicinal properties of the muriate. It is limpid, tranſparent, and colourleſs; but is rapidly decompoſed by the earthy, metallic, and alkaline ſulphates and nitrates; the alkaline phoſphates, borates, and carbonates, being precipitated in the form of a white powder. Its affinity for ſulphuric acid is ſo great, that, as a re-agent, it is capable of detecting 0.00009 of that acid in any fluid.

This ſolution is ſtimulant and deobſtruent, and in large doſes poiſonous. It was introduced into practice by the late Dr. Crawford as a remedy for cancerous and ſcrophulous affections; and its uſe was afterwards extended to ſyphilis. When taken in moderate doſes, it appears to increaſe the ſecretion by the ſkin, augments the flow of urine, and improves the tone of the ſyſtem; but by large doſes, violent vomiting, purging, vertigo, and the moſt dangerous ſymptoms, are produced. It has undoubtedly been found beneficial in ſeveral inſtances of ſcrophula, in ſome cutaneous affections, and in ulcerations connected with elephantiaſis; while in ſyphilis it has the power of ſuſpending ſome of the ſymptoms for a ſhort period. But although it be a medicine of ſome efficacy, yet, to uſe the words of Mr. Pearſon, in whoſe opinion of its deficient powers as an antiſyphilitic we place implicit faith, its "good qualities are uncertain in their operation, and narrowly circumſcribed; nor is it a preparation on which great confidence can be placed for the cure of any diſeaſe." The doſe requires to be carefully apportioned, and very gradually increaſed, until from ♏ v, which are ſufficient at firſt, ♏ xx be taken twice a day; or more, if nauſea be not excited.

It is ſometimes uſed externally as an eſcharotic to fungous ulcers and ſpecks on the cornea. Thomſon's Diſp.

Phoſphate of Barytes.—The moſt ſimple proceſs for forming this ſalt, is to add a ſolution of phoſphate of ſoda to a ſolution of muriate of barytes. The acids exchange baſes, and the phoſphate of barytes is precipitated in the form of a white powder, having no taſte. This ſalt is not ſoluble in water. Its ſpecific gravity is 1.2867. With the heat of a furnace it melts into a white enamel. Its compoſition is not known by analyſis, but by theory it ſhould conſiſt of

Barytes	-	74.5
Phoſphoric acid		24.5
		99

The phoſphorous acid combines with barytes by treating phoſphate of ſoda with the muriate of barytes. It is inſoluble like the laſt, and has no very diſtinguiſhing characters.

Fluate and Borate of Barytes.—Little known.

Carbonate of Barytes.—This ſalt exiſts in nature in ſeveral parts of England. It was firſt diſcovered by Dr. Withering, and has been very improperly called *Witherite.*

The form of its cryſtals in the native ſtate is various. It is found with double pyramids, ſometimes with ſix and alſo with four ſides. It alſo occurs in ſix-ſided priſms, terminated by ſimilar ſided pyramids. It frequently appears like bundles of needles radiating from a point. Its ſpecific gravity is 4.331. It is ſaid to be ſoluble in $\frac{1}{4304}$ of cold, and $\frac{1}{2304}$ of boiling water. It is not altered by expoſure to the air. Its compoſition, according to Withering, is

Carbonic acid		20
Barytes	-	80
		100

According to Pelletier, it is compoſed of

Acid	-	22
Barytes	-	62
Water	-	16

This salt may be prepared artificially by adding carbonate of potash to muriate or nitrate of barytes. The salt is precipitated in a white powder, which requires to be separated by filtering, washing, and drying. This powder is of the specific gravity 3.763. Its composition, according to Bergman, is

Acid -	7
Barytes -	65
Water -	28
	100

According to Kirwan, the ignited salt is

Acid -	22
Barytes -	78
	100

By Dr. Wollaston's scale, it is

Acid -	22
Barytes -	78
	100

By Dalton's numbers,

Acid -	22
Barytes -	78

There is in all probability a bicarbonate of barytes, which is much more soluble in water. This would consist of

Acid -	38
Barytes -	68
	106

Arseniate of Barytes.—This is an insoluble salt, little known.

Molybdate and Chromate of Barytes.—Not known.

Acetate of Barytes.—This salt may be formed by dissolving the carbonate of barytes in acetic acid. By evaporation it affords crystals in the form of needles, which are six-sided prisms. It has an acid bitterish taste, and is soluble in water; it slightly effloresces in the air. See ACETITE *of Barytes.*

Oxalic acid in excess, added to barytes, constitutes a superacetate, which affords crystals, and is sparingly soluble in water. When neutral it becomes an insoluble powder.

Tartrate of Barytes.—Not known.

Citrate of Barytes.—Citric acid dissolves barytes, forming at first a white powder, but gradually assumes the form of silky flakes of a beautiful appearance.

Benzoate of Barytes is soluble in water.

The rest of the salts of barytes are at present but little known.

Sulphate of Ammonia.—This salt is formed by saturating carbonate of ammonia with sulphuric acid. By evaporation it affords crystals, which are six-sided prisms, terminated by six-sided pyramids. These are extremely small, like needles, when the evaporation is too rapid.

Its taste is sharp, bitter, and disagreeable. It dissolves in two parts of water at 60°, and in half that quantity of boiling water.

It becomes moist by exposure to the air.

When heated it decrepitates. If the heat be continued it sublimes, losing a part of the alkali, and passing to the state of a super-salt. The heat at length favours the decomposition of the acid by the hydrogen of the ammonia, by which azotic gas is produced.

Its composition, according to Kirwan, is

Acid -	54.66
Ammonia	14.24
Water -	31.1
	100

By Dalton's numbers, and supposing the salt to be constituted by one atom of acid to two atoms of ammonia, we have

Acid -	74
Ammonia	26

See CARBONATE *of Ammonia.*

Nitrate of Ammonia.—This salt is formed by adding carbonate of ammonia to nitric acid till the effervescence ceases. On evaporation this salt crystallizes in long prismatic crystals, terminating in pyramids. To give them the latter form, the evaporation is made with a low heat, not more than 100°. When evaporated at the boiling point, the crystals assume a fibrous form. If the heat be still raised higher up to 250° or 300°, the mass on cooling assumes a compact form.

The taste of this salt is very acrid and disagreeable. Its specific gravity is 1.5785. It is soluble in two parts of cold, and in half its weight of boiling water. It is deliquescent in the air.

When the crystals of this salt are put into a glass retort, and placed over an Argand lamp, it melts at about 100°. By keeping it in a boiling state, the water distils over, and the heat requires to be gradually raised in order to keep up the distillation. When the temperature reaches about 450°, a number of bright bubbles begin to appear on the surface, assuming a different appearance to that of the boiling of a fluid. These bubbles result from the decomposition of the salt, and are no other than the gas called nitrous oxyd, which comes rapidly over. The whole salt is, in this process, converted into water and nitrous oxyd, and ultimately the retort becomes empty. (See NITROUS OXYD.) The decomposition of this salt sufficiently points out its constituents, and admits of a simple explanation by Dalton's numbers. His number for nitric acid is 19, *viz.* 1 of azote 5 + 2, of oxygen 2 × 7. His atom of ammonia consists of 1 of azote, 5, and 1 of hydrogen, 1, and the number for it will be 6. The nitrate of ammonia is therefore constituted by 1 atom of nitric acid, 19, and 1 of ammonia, 6. An atom of hydrogen in the ammonia combines with 1 of oxygen in the nitric acid, forming water, and the azote of the ammonia combines with the other atom of oxygen and azote of the nitric acid, forming an atom of nitric oxyd, which is constituted by 1 atom of oxygen and 2 of azote. The whole salt being made of 2 oxygen = 14, 2 azote = 10, and of 1 of hydrogen = 1, the whole being 25, the result will be 1 + 7 = 8 water, and 7 + 2 × 5 = 17, the nitrous oxyd. Hence the salt will be *per cent.* without water,

Acid	76
Ammonia	24
	100

The ſalt in priſmatic cryſtals will contain an atom of water, and will then be, acid 57.5, ammonia 18.2, water 24.3; amounting to 100.

According to Kirwan's analyſis, it is acid 57, ammonia 23, water 20; amouning to 100. See Ammonia.

Muriate of Ammonia. See Sal *Ammoniac.*

Phoſphate of Ammonia.—This ſalt is prepared, like the laſt, by adding carbonate of ammonia to phoſphoric acid.

By evaporation it forms cryſtals in the form of four-ſided priſms, terminated by pyramids. When theſe are ſmall they appear like needles. It has, like moſt of the ammoniacal ſalts, a ſharp diſagreeable taſte.

It diſſolves in two parts of water at 60°. It is deliqueſcent in the air.

When heated in a retort, the ſalt firſt parts with ſome ammonia, leaving the ſalt in the ſtate of a ſuper-ſalt.

The acid undergoes decompoſition, probably from the hydrogen of the ammonia, as ſome phoſphorus comes over diſſolved in ammonia, and in the ſtate of phoſphuretted hydrogen. Ultimately all the ammonia is expelled, leaving the phoſphoric acid in the ſtate of glaſs.

There ſeems to be no accurate analyſis of this ſalt.

Fluate of Ammonia.—This ſalt is obtained by ſaturating carbonate of ammonia with liquid fluoric acid. It cryſtallizes and ſublimes by heat.

Subcarbonate of Ammonia.—To form this ſalt in a ſtate of purity, let five parts of dry powdered chalk be mixed with three of muriate of ammonia, alſo very dry and in powder. Place the mixture in a crucible of cloſe texture, having a groove round the top; let a diſh-like or conical veſſel of the materials be inverted over this, and filling the groove. This latter veſſel ſhould have a ſmall hole in the top, with a ſtopper, to remove occaſionally. Place the lower veſſel in a gentle ſand heat. The carbonic acid of the carbonate of lime combines with the ammonia of the muriate, forming carbonate of ammonia, which ſublimes at the heat of boiling water. This ſalt condenſes into a cake in the inverted veſſel, having a cryſtalline texture. In this ſtate it is ſold in the ſhops, under the name of volatile ſalt.

It is of a fine white colour, having a ſtrong ſmell of ammonia, and a ſlightly acrid yet cooling taſte. It changes moſt vegetable blues to green. Its ſpecific gravity is 0.966. It is inſoluble in alcohol, but diſſolves in two parts of cold water, and is much more ſoluble in hot water. Boiling water volatilizes it. This laſt property has rendered it uſeful to paſtry cooks. It is diſſolved in the water or milk with which the paſte is made. In the baking, the ſalt riſes in vapour, and makes the paſtry light and honey-combed. When expoſed to the air, it ſoon loſes its ſtrong ſmell, and is converted into a ſalt, which contains juſt half the quantity of ammonia, and which is named *carbonate of ammonia.*

The compoſition of this ſalt has the appearance of being very irregular.

When newly formed its proportions are, by Dr. Wollaſton's ſcale, carbonic acid 44, ammonia 56; amounting to 100.

When it has been expoſed to the air till it has no ſmell, its compoſition will be, acid 82, ammonia 18; amounting to 100.

Bergman makes its conſtituents to be 45 parts of carbonic acid, 43 ammonia, and 12 water,—in 100 parts; by which there would appear to be ſeven grains of ammonia in exceſs; but ſir Humphrey Davy has found, that the quantity of alkali varies according to the temperature that has been employed in the preparation: thus, when it is formed at a temperature of 300°, it contains rather more than 50 *per cent.* of ammonia; but produced at a temperature of 60°, it contains only 20 *per cent.*

The carbonate of ammonia of the Lond. Pharm. is formed by pulverizing ſeparately one pound of muriate of ammonia, and two pounds of prepared chalk, dried: then mixing them, and ſubliming with a gradually increaſed heat, until the retort becomes red-hot. The carbonate of ammonia of the Edinb. Pharm. is prepared by taking one pound of muriate of ammonia, and two pounds of ſofter carbonate of lime, dried, pulverizing each of them ſeparately, mixing them, and ſubliming from a retort into a receiver kept cold. That of Dublin is formed by mixing muriate of ammonia, reduced to powder, and well dried, carbonate of ſoda dried, of each half a pound; putting them into an earthen retort, and ſubliming with a heat gradually increaſed into a receiver kept cold. This ſalt, notwithſtanding the name by which it is deſignated in the reſpective colleges, is merely a ſubcarbonate. Subcarbonate of ammonia is decompoſed by the acids, the fixed alkalies, barytes and lime, and partially by magneſia.

As an article of the Materia Medica, this ſalt is ſtimulant, antiſpaſmodic, antacid, diaphoretic, and in large doſes emetic. It is beneficially given in gout, hyſteria, and dyſpeptic affections, when much acid is preſent in the ſtomach; and in infantine convulſions connected with dentition, or with acidity of the primæ viæ. As a diaphoretic it is occaſionally exhibited in chronic rheumatiſm, in combination with guaiacum; and ſometimes, though rarely, it is employed to produce vomiting in gouty and paralytic caſes. From the ammonia it contains in exceſs, the ſubcarbonate is applied as a local ſtimulant to the noſtrils in ſyncope, hyſteria, and languors; and with the addition of a little ſcent forms the common ſmelling ſalts of the ſhops. The ordinary doſe is from grs. v to grs. xx, formed into pills, or diſſolved in any aqueous vehicle; but to excite vomiting ʒſs may be given for a doſe, and repeated, if neceſſary, aſſiſting its operation by plentiful dilution.

Its officinal preparations are as follow: *viz.* "Liquor ammoniæ carbonatis," or ſolution of carbonate of ammonia, which the Lond. Pharm. directs to be prepared by diſſolving 8 oz. of carbonate (ſub-carbonate) of ammonia in a pint of diſtilled water, and filtering through paper. The "Aqua carbonatis ammoniæ," or water of carbonate of ammonia, formerly water of ammonia, or ſpirit of ſal ammonia, of the Edinb. Pharm. is formed by pouring 2 lbs. of water on muriate of ammonia and carbonate of potaſs, of each 16 oz. mixed and put into a glaſs retort; then diſtilling to dryneſs, from a ſand-bath, with a fire gradually raiſed. The water of carbonate of ammonia of the Dubl. Pharm. is prepared, by diſtilling, with a fire gradually raiſed, 2 pints from a pound of muriate of ammonia, 28 oz. of carbonate of ſoda, and 3 pints of water. The ſpecific gravity of this liquor is to that of diſtilled water as 1095 to 1000. This ſolution has the odour and taſte of the concrete ſub-carbonate; it is limpid and colourleſs; and when ſhaken with twice its bulk of alcohol, a coagulum, nearly uniform, is formed. Its medical properties and uſes are the ſame with thoſe of the concrete ſalt. It is given in doſes of from fʒſs to fʒj in any bland fluid.

Other preparations of the carbonate (ſub-carbonate) of ammonia, are the London "Carbonate of potaſh," the "Carbonate of ſoda," (ſee Carbonate, Potash, and Soda,) the "Liquor ammoniæ acetatis," (ſee the next article,) and "Cuprum ammoniatum." The latter is formed according to the direction of the Lond Pharm. by rubbing together in a glaſs mortar half an ounce of

ſulphate of copper and 6 drachms of ſubcarbonate of ammonia until the effervefcence ceafes; then wrapping up the ammoniacal copper in bibulous paper, and drying it with a gentle heat. The "Ammoniaret of copper" of the Edinb. Pharm. is obtained by rubbing thoroughly together in a glaſs mortar 2 parts of pure ſulphate of copper with 3 parts of carbonate of ammonia, until the effervefcence is finiſhed, and they unite in a violet-coloured maſs, which, wrapped up in bibulous paper, is dried, firſt on a chalk ſtone and afterwards with a gentle heat. It is preſerved in a well-ſtopped glaſs phial. The Dublin Pharm. directs the ammoniated copper to be prepared by rubbing an ounce of ſulphate of copper with an ounce and a half of carbonate of ammonia, in an earthenware mortar, until the effervefcence has ceaſed, and they unite in a maſs, which is dried, wrapped up in bibulous paper, or preſerved in a phial cloſed with a glaſs ſtopper. See Copper.

This preparation has the odour of ammonia, a hot, ſtyptic, metalline taſte, and a rich blue colour. Expoſure to the air deſtroys the blue colour, and gives the ſalt a greeniſh hue. Ammoniated copper is tonic and antiſpaſmodic. It has been principally employed in epilepſy, as a remedy for which it was firſt propoſed by Dr. Cullen, and it has ſince been employed with advantage; though Mr. Thomſon ſuggeſts from his own trials that it does not warrant any great dependence. The doſe is gr. ½, gradually increaſed to grs. v, given twice a day, either ſimply in pills of crumb of bread, or combined with valerian. The ſolution of ammoniated copper (Lond. Pharm.) is formed by diſſolving a drachm of the copper in a pint of diſtilled water, and filtering the ſolution through paper; or the water of ammoniated copper (Dub. Pharm.) is prepared by mixing together 8 fluid-ounces of lime-water, 2 ſcruples of muriate of ammonia, and 4 grains of prepared verdigris, digeſting for 24 hours, and pouring off the clear liquor. This ſolution is detergent and mildly eſcharotic; and it forms an uſeful local ſtimulant for cleaning foul indolent ulcers, and diſpoſing them to heal; and it is alſo employed, ſtill more largely diluted, for removing ſpecks from the cornea. Thomſon.

The arſeniates, molybdate, and chromate of ammonia, are but little known.

Acetate of Ammonia. (See Acetate *of Ammonia.*) Its cryſtals, which are difficult to obtain from the volatility of the ſalt, are in the form of needles.

It is capable, like the carbonate and muriate of ammonia, of being ſublimed when its cryſtals are much more complete.

Theſe are of a pearl-white colour. It has a ſweetiſh cooling taſte.

It is deliqueſcent in the air. It melts at 170°, and is volatile at 250°.

Its compoſition has not been determined with preciſion.

The "liquor ammoniæ acetatis" of the Lond. Pharm. is prepared by adding four pints of (diluted) acetic acid to two ounces of (ſub) carbonate of ammonia, until the effervefcence ceaſes. The "water of acetite of ammonia," (Edinb.) or "ſpiritus Mindereri," is formed by pouring on any quantity of carbonate of ammonia in powder as much diſtilled acetous acid as will exactly ſaturate the ammonia. The "water of acetate of ammonia" (Dubl.) is prepared by adding in ſmall portions, with frequent agitation, 3½ pints of diſtilled vinegar to two ounces of carbonate of ammonia, or as much as will ſaturate the ammonia, which may be aſcertained by means of litmus. This ſolution is inodorous, has a ſlightly nauſeous taſte, and when made with pure materials, is limpid and colourleſs. It is decompoſed by acids, the fixed alkalies, the ſtrong acids, oxymuriate of mercury, and nitrate of ſilver, which are therefore incompatible with the formulæ preſcribing the uſe of it. As a diaphoretic it is in common uſe in febrile diſeaſes, combined with opium, camphor, antimonials, or nitrate of potaſh. It is neceſſary to aſſiſt its determination to the ſkin with plentiful dilution, and a moderate degree of external heat; for by free expoſure to cool air it excites the kidnies, inſtead of opening the ſkin. Externally, it is employed as a diſcutient; as a lotion to inflamed ſurfaces; and when diluted with roſe-water holding in ſolution a ſmall portion of opium, it is an excellent collyrium in chronic ophthalmia; and ſtill more largely diluted, is occaſionally uſed as an injection in the commencement of gonorrhœa. The ordinary doſe is from f℥ij to f℥xij, given every three or four hours. Thomſon. See Ammonia, and Sal *Ammoniac.*

Oxalate of Ammonia.—This ſalt is formed like the laſt. It does not cryſtallize; it is employed in ſolution as a chemical teſt for lime.

Tartrate of Ammonia.—This ſalt has a cooling, bitter taſte, and is very ſoluble in water. It is decompoſed by heat. It combines with exceſs of acid, forming a ſalt of little ſolubility, ſimilar to the ſupertartrate of potaſh.

Salts, *Earthy*, are compounds of the acids with the pure earths, reſembling the ſalts formed by the combination of acids with alkalies. Some of them are cryſtallizable, and ſoluble in water; others are nearly inſoluble: ſome of them, conſidered in a medical view, exert ſcarcely any action in the animal economy; while others are poſſeſſed of great activity, and produce very ſtriking effects.

The following Table, which we extract from "Thomſon's London Diſpenſatory," ſhews the ſolubility of the above earths, and of the compounds which they form with acids.

Pure Earths.	Solubility in one Part of Water.	Acids which, in combination with theſe Earths, form		
		Soluble Compounds.	Compounds ſcarcely ſoluble.	Inſoluble Compounds.
Lime	0.002	Nitric Muriatic Acetic Benzoic	Sulphuric Boracic	Phoſphoric Carbonic Arſenic
Magneſia	0.000	Sulphuric Phoſphoric Nitric Muriatic Acetic Benzoic Succinic	Boracic	Carbonic
Barytes	0.050	Nitric Muriatic Acetic Benzoic	Succinic	Sulphuric Phoſphoric Carbonic Boracic Arſenic
Alumina	0.000	Sulphuric Nitric Muriatic Acetic Benzoic		Phoſphoric Carbonic Boracic Arſenic

The following Table, extracted from the valuable work already cited, and formed on the more general table of Dr. Thomson, in his excellent "Syſtem of Chemiſtry," 4th ed. iii. 568, preſents a ſynoptical view of the neutral ſalts with alkaline and earthy baſes, employed as remedies, or for pharmaceutical purpoſes.

Salts.	Taſte.	Figure of Cryſtals.	Action of Air.	Solubility in 100 parts of Water		Action of Heat.
Sulphate of barytes	None	Rhomboidal priſms	None	0.002	0	Decrepitates.
——— potaſh	Bitter	Six-ſided priſms	None	6.25	24	Decrepitates.
——— ſoda	Bitter	Six-ſided priſms	Effloreſces	35	125	Watery fuſion.
——— magneſia	None	Four-ſided priſms	Effloreſces	100	133	Watery fuſion.
Alum	Aſtringent	Octahedrons	Little	5	133	Watery fuſion.
Nitrate of potaſh	Cooling	Six-ſided priſms	None	14.3	100	Melts.
Muriate of barytes	Aſtringent	Four-ſided priſms	None	43		Decrepitates.
——— ſoda	Salt	Cubes	None	35.46	36.16	Decrepitates.
——— lime	Bitter	Six-ſided priſms	Deliqueſces	400		Watery fuſion.
——— ammonia	Acrid	Four-ſided pyramids	Subdeliqueſces	31		Sublimes
-- magneſia	Bitter	Needles	Deliqueſces	151		Watery fuſion.
Hyperoxymuriate of potaſh	Cooling	Rhomboidal plates	None	6	40	Gives out oxygen.
Phoſphate of lime	None	Six-ſided priſms	None	0	0	Little.
——— ſoda	Salt	Rhomboidal priſms	Effloreſces	25	50	Watery fuſion.
Borax	Styptic	Six-ſided priſms	Subeffloreſces	5	16.8	Watery fuſion.
Carbonate of barytes	None	Various	None	0.023	0.043	Little.
——— lime	None	Rhomboidal priſms	None	0	0	Decrepitates.
——— potaſh	Alkaline	Four-ſided priſms	None	25	$83\frac{1}{3}$	Watery fuſion.
——— ſoda	Alkaline	Octahedral truncated	Effloreſces	50	100 +	Watery fuſion.
——— magneſia	None	Six-ſided priſms	Effloreſces	2		Decrepitates.
——— ammonia	Urinous	Irregular	None	50 +		Evaporates.
Acetate of potaſh	Hot	Plates	Deliqueſces	99		Melts.
—- ammonia	Cool	Slender priſms	Deliqueſces	Very ſoluble		Melts and ſublimes.
Tartar	Acid	Irregular priſms	None	$1\frac{2}{3}$	$3\frac{1}{3}$	Melts.
Tartrate of potaſh	Bitter	Four-ſided priſms	None	25		Melts.
——— potaſh and ſoda	Bitter	Eight-ſided priſms	Effloreſces	25		Melts.

Salts, *Metallic*. See Metals, in the *Materia Medica*. The reader is deſired to inſert in that article, for Todd's London Diſpenſatory, Todd Thomſon's, &c.

Salt, *Bitter*, *Purging*, or *Epſom*. See Sal, Epsom *Salt*, and *Sulphate of* Magnesia.

Salts, *Cryſtallizable*, in *Chemiſtry*, diſtinguiſh and comprehend all ſaline matters ſuſceptible of cryſtallization; in contradiſtinction to *fluor* Salts; which ſee.

Salt *of Colcothar* is a white ſaline matter, obtained by lixiviating colcothar.

Salts, *Deliqueſcent*, a denomination comprehending all ſaline matters, which may be obtained by cryſtallization, or drying in a concrete form, but which, when expoſed to the air, imbibe its moiſture, and loſe their concrete cryſtallized form, deliquiating into a liquor by means of this moiſture. See Deliquescence.

Salt, *Diuretic*. See Sal *Diureticus*, and Acetate *of Potaſh*.

Salt *of England*, is a name given to a very rectified, concrete, volatile alkali obtained from ſilk; and alſo to the concrete volatile alkali obtained from ſal ammoniac.

Salts, *Eſſential*, include all concrete ſaline matters which preſerve the ſmell, taſte, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable or animal. The uſual method of preparing them is by evaporating, to almoſt the conſiſtence of a ſyrup, the liquors containing the eſſential ſalt, *viz*. the expreſſed and depurated juices and ſtrong decoctions, and by keeping them in a cold place. From many of theſe liquors, ſaline matters or cryſtals are depoſited upon the ſides of the containing veſſels after a conſiderable time, and after they have undergone a kind of fermentation. Theſe cryſtals, which are always very red, may be purified by diſſolving them in water, filtrating, evaporating, and cryſtallizing. Theſe mineral ſalts are extraneous to the vegetables and animals from which they are obtained; and are procured in the ſame ſtate in which they were introduced. The beſt known of theſe eſſential ſalts is *tartar;* which ſee.

Salts, *Fixed*, a name given by many chemiſts to the ſalts obtained from the aſhes of plants, which, not having been diſſipated by fire, ought to be conſidered as fixed, in compariſon of the other ſaline matters of theſe plants, which evaporate during their deflagration. As the ſaline ſubſtances remaining in the aſhes of vegetables are entirely or chiefly alkaline, the name of fixed ſalt has become ſynonimous with that of *Fixed* Alkali; which ſee. But other ſaline ſubſtances, as moſt neutral ſalts, which have not baſes of volatile alkali, are nearly as fixed as fixed alkali.

Salt, *Foſſile*. See Rock-*Salt* and *Common* Salt.

Salts, *Fluor*, diſtinguiſh and include all ſaline ſubſtances, which cannot by any method be rendered ſolid; ſuch are nitrous and marine acids, volatile alkali altered by quicklime, and ſome others.

Salt, *Fuſible*, *of urine*, called alſo *native* or *eſſential ſalt*

of urine, phosphoric salt, and *microcosmic salt*, is a neutral salt, composed of phosphoric acid, saturated with an alkali fixed or volatile.

It is best prepared from putrefied human urine; but it may be prepared from fresh. A quantity of the urine of sound beer-drinking men being putrefied in a moderate heat, and then slowly boiled in glazed earthen vessels to the consistence of a syrup; if this liquor be placed in a cellar or cool place, in about four weeks time, or sooner in winter, crystals of a peculiar figure will be formed. But these, being impure, must again be dissolved in a sufficient quantity of water, and filtered as hot as possible through grey paper, and the solution again put in a cool place, where, in a few days, crystals will again be formed much cleaner than the former. These being separated from the liquor and dried, the operations of solution, filtration, and crystallization, must be reiterated twice or thrice, till the salt becomes perfectly white and without smell.

Mr. Margraff says, that a hundred, or a hundred and twenty measures of urine, give about three or four ounces of this salt, which always crystallizes first, and is easily distinguished from that which appears afterwards in crystals of a long and cubical form.

This salt is ammoniacal, but of a peculiar nature. It is a saline acid body. By distillation an urinous volatile spirit first rises. The residuum may be reduced by a violent fire into a pellucid white transparent mass like glass, of a very fixed nature, and from which neither acid nor any thing else can be separated, without the addition of some other matter.

This vitreous substance may be entirely dissolved in two or three parts of distilled water, and is thereby changed into a transparent liquor, somewhat thick, not unlike the concentrated oil of vitriol, and having the properties of all acids, such as fermenting with volatile and fixed alkalies, forming neutral salts with them, precipitating bodies dissolved in alkaline menstruums, and dissolving alkaline earths. It does not dissolve gold nor silver: and copper, tin, and lead little, but iron very strongly. It extracts a red colour from *cobaltum pro ceruleo*, in German, *blau farben kobalde*, the mineral by which glass is tinged blue.

But this salt in its dry state attracts metals with much more vigour, and with them produces several remarkable and singular phenomena; for all which, as also for the relation their salt bears to acid, alkaline, and neutral salts, we refer to the learned author, who has also examined its effects on several solutions of terrestrial bodies. One most eminent property is, that mixed with the inflammable part of soot, and dissolved in a close vessel, it produces a phosphorus. An ounce of this salt of urine, thus separated from its urinous part, and exactly mixed with half an ounce of soot, affords in this way a drachm of the best phosphorus. The residuum did not produce any when tried.

The learned author does not pretend to determine exactly the true origin of this salt; he thinks its acid may come into the human body from vegetable aliments. He has observed elsewhere, that cresses, mustard, rocket, and even corn, exposed to a very violent fire, produce a phosphorus. Hence he thinks this acid must be mixed with those substances; and the like may happen in other vegetables. He thinks this conjecture strengthened, because urine in summer, when people eat most vegetables, always produces this salt in the greatest quantity. Margraff in Mem. de l'Acad. de Berlin, 1746. See also Miscel. Berol. tom. vii. p. 341.

Mr. Pott observes, that the figure of fusible salts varies much according to the heat, evaporation, and different mode of crystallization; and that it assumes the shape of most others, as of saltpetre, vitriol, sal ammoniac, Glauber's salt, &c. but it is generally in shining, octagonal, prismatic crystals. The taste of this salt is cool, resembling that of borax, to which it is in other respects similar. When put on the fire in a crucible, it froths, swells, and melts. When melted upon a bit of charcoal, by means of a blowpipe, it forms a round drop. The crystals of the second crystallization do also melt upon charcoal, when they are pure, but when cold they have a milky colour. They do not, like the crystals of the first crystallization, form phosphorus with phlogiston. They effloresce in the air, and are hot to the taste, in both which instances they also differ from the first crystals.

SALT *of Glass*, called also *Glass-gall*, is a kind of saline scum or mass, found in glass-house pots upon the surface of the melted glass. It consists of neutral salts, as common salt, vitriolated tartar, and others, which are contained in the soda and potash employed in the composition of glass, and which not being themselves susceptible of vitrification, are separated from the glass during the fusion, and collected together upon its surface, because they are specifically lighter. See GLASS, and SANDEVER.

SALT, *Glauber's*. See SAL, and *Sulphate of* SODA.

SALT *of Hartshorn*. See CARBONATE *of Ammonia*.

SALTS *of Count Lagarais*, a name by which the French and some other nations call a preparation of vegetable bodies, invented by the gentleman whose name it bears, but very improperly called by him a salt.

The history of these preparations is this: in the year 1731, the count de Lagarais shewed the French king some powders, which proved to be very useful in medicine, and which he called the *essential salts of certain plants*. The method of making these was long kept a secret, but at length, the discoverer publishing it to the world, it appeared that they were made by means of water only, agitated in a violent and continued manner in a close vessel with an instrument resembling a chocolate mill. Mr. Langelot had before attempted a resolution of this kind of vegetable, and other substances, by means of water and motion, but his was done by grinding them with a small quantity of water at a time; whereas this of the count's is by powdering the ingredients, mixing them with a large quantity of water, and breaking them to pieces by a continued motion of this sort of mill made with four vanes, or flaps of thin wood, which was kept for six or eight hours in a continual motion, by means of a larger wheel, such as the lapidaries polish stones with.

There is no doubt but that the instrument used by the count is of very great use, and that the result of the operation is a very valuable form of medicine; but it is not a salt, but an extremely fine extract, containing the gummy, resinous, and saline parts of the body, and in a form capable of being reduced to powder, and easily administered, as it contains the virtues of the plant it is made from, in an extremely small compass, and is capable of ready solution in aqueous fluids. It is certainly a form of medicine worthy to be brought into practice, and must be a very proper way of administering the more bulky medicines to children, and persons of tender constitutions.

To give a proper view of the nature of these preparations, and their difference from the extracts made in the common manner, it may be proper to enter, in some degree, into the manner of preparing the two forms. The common extracts of the shops are made either from the juices of succulent plants, as houseleek, purslane, or the like; or from a strong

decoction of the other drier plants in common water, which, when feparated from the coarfer parts by fubfidence, filtration, or the like means, are evaporated over a balneum Mariæ to the confiftence of a thick honey.

In procefs of time, an effential falt will feparate itfelf from thefe extracts, and many plants have, in the decoctions, a large quantity of a fine fubftance, which will never be made to pafs the filter; and the extracts, made by this means, contain the oil, the gummy and refinous parts of the plants, and the effential falts, though this is but in a very inconfiderable quantity. Thefe are the common extracts of plants.

The method of making thofe extracts, called *count Lagarais's falts*, is this. They choofe a glafs veffel, capable of holding fix or feven pints, and having a wide mouth; into this they put an ounce of bark, fena, guaiacum, or any other vegetable of which they are to make the extract, firft reduced to a coarfe powder. They pour on this two pints and a half of rain-water, or diftilled water, and then taking the veffel to the place where the mill is fixed, they raife it fo high, that the body of the mill is in the middle of the liquor; then they cover the top of the veffel with a wet bladder, that the froth may not be thrown over, and then turning the large wheel, they make the mill move round very fwiftly in the liquor for fix or feven hours together; after this they let the liquor fettle for an hour or two, till only the finer parts of the body remain fufpended in it, and then pour it off into a number of flat China or ftone-ware difhes, putting only a fmall quantity into each difh, and thefe they fet in the fun, or over a balneum Mariæ prepared on purpofe; for fhould they attempt the evaporation in a fand heat, the fmall quantity of extract in each difh would be burned. When the whole is evaporated to a drynefs, there remains on the whole inner furface of the difhes a thin cruft of an extract, which is to be feparated by fcraping it off with a piece of ftiff paper, and referved for ufe. This always breaks up in fmall fcales, which have a very fhining furface on that part where they adhered to the difhes, and it feems that this has given occafion to fome to believe, that they were particles of real falt.

There is no doubt but this method of procuring a powerful extract might be of great ufe, in regard to all thofe fubftances which water can have power to penetrate; but it is not eafy to give credit to its being able to make the like valuable medicines from the metals, though that has been pretended. Gold and filver are pretended to be operated on in a powerful manner by it, but there feems a fallacy in this, fince even iron itfelf, which is much more penetrable by water than thofe metals, yields but little virtue to it; two ounces of the filings of this metal yielding, with the utmoft care and accuracy, only about four grains of a white earthy matter, which is alfo much more likely to be a part of the water than of the metal.

The *falts of the metals*, as the count called them, which were prepared by this means, were always fufpected to hold fome faline quality, which they owed to the menftruum, which, whatever was pretended, was not fimple water, and a ftrict examination of them always difcovered a marine falt among them. It is true, indeed, that according to Langelot's method of grinding, fome leaves of gold were reduced, by the addition of a very fmall quantity of water, into a liquor, from which, on diftillation, a few red drops were feparated; but it is to be obferved, that as Langelot's method is the grinding of the fubftance with great vehemence, and for a long time, in an iron mortar, with a peftle of the fame metal, there is reafon to fufpect, that what was found to come forth in red drops was a folution of iron, not of gold, as was pretended by thofe who firft prepared them.

It is not to be doubted, but the method of evaporation of count Lagarais's medicines is of great ufe, fince no other can fo well retain the finer parts of the medicines. Mr. Geoffroy tried it on rofes, violets, and fome other flowers, and found great reafon to wifh that all the medicinal extracts could be prepared in the fame manner; but the method is impracticable, when medicines are to be prepared for general ufe; for though the mills might be made to be moved in great numbers at once, by a current of water, and fo this part of the work performed with tolerable eafe, yet the evaporations, in fuch quantities, could by no means be made in any tolerable room, or time, and they muft be evaporated as foon as made, fince they very quickly turn four, and lofe all the virtues. Mém. de l'Acad. Scienc. Par. 1739. See EXTRACT.

SALT *of Lead*. See *Salt of* LEAD, and SACCHARUM *Saturni*.

SALTS, *Lixivial*, a general name given to all faline fubftances obtained by lixiviation of afhes, but particularly applied to *fixed alkali*.

SALT *of Milk*. See MILK.

SALT, *Microcofmic*. See *Fufible* SALT *of Urine*.

SALT *of Mineral Waters*. See HALCRYPTIUM.

SALT, *Muriatic calcareous*. See SAL *muriaticus calcareus*.

SALTS, *Neutral*. See NEUTRAL, and the diftribution of faline fubftances at the beginning of the article SALTS.

SALT, *Neutral arfenical*, is a combination of arfenic with fixed alkali to the point of faturation. M. Macquer firft difcovered this combination, and began an account of its properties in the Memoirs of the Royal Academy for 1746 and 1748. His method of making this falt, is, by mixing together equal parts of very white cryftalline arfenic and purified nitre, and by diftilling this mixture in a retort with a graduated heat, in the ufual manner, till the retort is red-hot, and no more vapours of nitrous acid arife. In the retort there remains a faline mafs, white, compact, and fixed; from which, after folution in hot water, filtration, evaporation, and cryftallization, may be obtained beautiful, quadrangular, prifmatic cryftals, terminated at each end by a quadrangular pyramid, the fides of which correfpond with thofe of the prifm. This new falt is precifely neutral, and exhibits no marks of an alkaline quality. It is infinitely more foluble in water than pure arfenic, and diffolves in a lefs quantity of hot than of cold water. It is eafily fufible by fire, and remains fufed and tranfparent like glafs, without being alkalized, if it has not touched any inflammable matter; for it may be eafily decompofed by phlogifton, which unites with the arfenic, feparates it from the alkali, and is fublimed. This falt cannot be decompofed by any pure mineral acid, becaufe arfenic feems to have a greater affinity with fixed alkali than acids have; but when thefe acids are united with metallic matters, they can eafily decompofe the neutral arfenical falt, even by the humid way; fo that a folution of this falt, added to a folution of metals, occafions a precipitate, compofed of the arfenic and metal, while the acid of the metallic folution combines with the fixed alkali of the neutral, arfenical falt, and forms another neutral falt. Macquer's Dict. Chemiftry, art. *Salt*.

SALT, *Pine*. See PINE.

SALT *of Rochelle*, or of *Seignette*. See RUPELLENSIS *Sal*, and *Tartrite of* SODA and POTASH.

SALT, *Sea*. See *Common* SALT.

Salt, *Sedative*, a name given by the modern chemists to a salt obtained from borax, by means of acids, of the virtues of which they boast much. Those who first described it, gave the process for making it in a very enigmatical manner; and their successors invented many different ways of preparing it. The truth is, that all mixtures of borax with the vitriolic acids furnish us with a sedative salt, as do all the mixtures of borax with spirit of nitre, or of sea-salt.

Becher first gave the enigmatic account of it, which Homberg traced to its origin, and found the way of making it with the vitriolic, as Lemery did with the other acids. This salt is formed by sublimation, and is a congeries of saline flowers, not a little approaching to flowers of benjamin. These flowers are so light and fine, that they swim upon water, and require a great quantity of water to dissolve them, and much more of cold than of boiling water; and, therefore, it may be crystallized by cold, and even by evaporation alone.

The sedative salt is a perfect *sal salsus*. It makes no alteration in the colour of the juice of violets, and has no sensible effect on the solution of corrosive sublimate, or on a solution of mercury in spirit of nitre for a long time; but it finally precipitates a yellow powder from it, as the borax does. There is this difference, however, between this precipitate, and that formed by crude borax, that the powder precipitated by the sedative salt does not, as the other, become white on washing with large quantities of water. These experiments shew this salt to be wholly analogous to tartarum vitriolatum, or to the Glauber's salts, in its effects.

When the composition of which this salt is to be made is placed on the fire, there arise different liquors before the salt appears; the first is a phlegm of a fattish complexion, and with the smell of soap; this is succeeded by a turbid white liquor, along with which there arise some of the first flowers. This makes a solution of mercury in spirit of nitre muddy after some time, and finally precipitates from it a small quantity of a white powder. After this all the salt or flowers ascend; these flowers, dissolved in warm water, recrystallize themselves in it when cold, assuming the same form with that they had in the flowers, except that the combinations of particles are more dense and heavy.

The usual method of making this salt by sublimation has been this. Take a glass retort, with a large neck; put into it four ounces of borax in fine powder, and pour on this half an ounce of common water, to wet it into a sort of soft paste; then add to this an ounce and two drachms of concentrated oil of vitriol; place the retort in a reverberatory furnace, and give at first a small fire, which raise by degrees till the retort is red-hot: there will pass over into the receiver about an ounce of aqueous matter; and after this the flowers, or sedative salt, will rise with a little more humidity; hence some part of the flowers will be dissolved in the liquor, and run over into the recipient, but the greater quantity will remain in form of a dry sublimation in the neck of the retort; they will finally stop up the whole orifice of the neck, and what arises after this usually forms a circle of a sort of glossy salt about their bases, out of which the flowers seem to shoot.

They are composed of multitudes of fine thin blades, or flakes, and are easily brushed out of the neck of the retort with a feather; the glossy circle at the bottom of them may be dissolved in water, and recrystallized, and by this means all the salt will be procured.

M. Geoffroy the younger has given, in the Memoirs of the Paris Academy, in 1732, an account of a way of making this salt by solution and crystallization alone, without the trouble of distilling; he has also summed up the several other ways of making it with blue and white vitriol, but the method here mentioned is that by which the chemists now make it.

Geoffroy's method by crystallization is as follows: take four ounces of borax, and one ounce one drachm of the most concentrated oil of vitriol; put the borax into a glass retort, pour in it half an ounce of common water after the oil of vitriol, and expose the mixture to a fire gradually increased: after the phlegm has passed off, and even while it is passing, there arise flowers, or a volatile salt, in beautiful foliated laminæ, some of which always melt by the heat of the fire; after the operation is over, the finest of the flowers are to be carefully gathered, and these are what stick to the neck of the retort. Those that are grey are to be thrown upon the remaining mass; this mass is to be dissolved in water, filtrated and evaporated gradually; sometimes, even without evaporation, the shining talcous laminæ are to be seen in the liquor; after twenty-four hours standing, the water is to be poured off from these laminæ, which are to be washed with fresh water, and then dried carefully in a warm place. If these crystals do not calcine in the place where they are put to dry, nor in the sun's heat, it is a sign there is nothing crystallized but the *sal neutrum*; if they do calcine, it is a proof that there is some Glauber's salt formed of the borax and the vitriolic acid, and crystallized in the mass. This sedative salt, obtained by crystallization, does not differ essentially from that which is sublimed, only that the crystals or laminæ of the latter are more separated and detached than those of the former. This salt, when once it has lost its water by drying, cannot be raised into vapours by the most violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does. Hence it appears that it is a saline compound, the principles of which are strictly united, and separable with great difficulty. This truth has been illustrated by numerous and accurate experiments on the subject, by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

M. Cadet has also published in the Memoirs for 1766, an account of experiments on this salt.

Homberg, the inventor of sedative salt, believed that he discovered in it a sedative, antispasmodic, and even narcotic quality, and thence called it the narcotic salt of vitriol; it was, therefore, generally employed in convulsive diseases; but its sedative powers have not been well ascertained. See Boracic *Acid*.

Salt *of Soda*, a name given to the marine or mineral alkali obtained from the ashes of soda, and of other maritime plants. See Kali.

Salt *of Sorrel*. See *Oxalat of Potash* under Salts, and Oxalis.

Salt, *Spirit of*. See Muriatic *Acid*.

Salt *of Stahl, Sulphureous*, a neutral salt, composed of volatile sulphureous acid, combined to the point of saturation with fixed vegetable alkali. This salt may be made either by saturating fixed alkali with volatile sulphureous acid, made in a cracked retort, in Stahl's manner, or by exposing linen, soaked in liquid fixed alkali, to the vapours of sulphur slowly burning. In the latter method, the linen dries, becomes stiff, and shines with many small needle-like crystals, which are the sulphureous salts. This has a more pungent taste than vitriolated tartar, is more soluble in water, and is crystallizable by cold. It may be decomposed by any acid, and its sulphureous acid expelled from it, and it is perpetually changing, from the constant dissipation (as former chemists suppose) of its phlogiston.

Salt *of Sylvius*. See Acetate *of Potash*, and Sal *Marinus Regeneratus*.

Salts *of Tachenius*, are impure fixed alkalies, obtained from the ashes of vegetables, burnt by suffocating their flame, and leaving no more communication with the air, than is sufficient for the burning of their most disengaged inflammable parts. The dried plant, in this process, is put in an iron pot, so heated, that its bottom may be red, and continually stirred, when a thick fume, and at length a flame, will rise from it. A lid must then be put on the pot, so loosely, that the smoke may escape but the flame be extinguished, and this lid must be occasionally removed for the convenience of stirring the plant. When it is thus reduced to ashes, the ashes must be lixiviated with boiling water; and when the lixivium has been evaporated to dryness, a saline matter, more or less reddish, will remain, which is Tachenius's fixed salt, and should be kept in a bottle. See the process described at large by Boerhaave, Chem. part ii. p. 28, &c. In this way of burning plants, the fixed alkali is phlogisticated, rendered semi-saponaceous, and mixed with all the neutral salts contained in the plants.

Salt *of Tartar*, the fixed alkali of *tartar* (which see); or this name is given to fixed vegetable alkali in general. See Carbonate *of Potash*.

Salt, *Vegetable*. See *Soluble* Tartar.

Salt *of Vinegar*, is a name given to *vitriolated* Tartar, impregnated with very strong *radical* Vinegar. See each article.

Salt, *Vitreous*, a term used by some modern chemists for a kind of salt, which till of late wanted a name, and which is found in, and separable from, the fixed alkaline salts of vegetables.

It is bitter, hard, fixed, and not alkaline, and of a crystalline, or glossy appearance.

The method prescribed by Boerhaave for the procuring it with the most ease, is this: put six pounds of the best pot-ashes into a clean glass, and add thereto twenty pints of cold rain-water; stir them together with a stick, and suffer the whole to rest. When the ashes are thoroughly dissolved, gently decant the clear lixivium, and there will be found at the bottom, mixed with the fæces, a number of small greyish granules, of a bitter taste, and of an almost glassy brittleness and hardness; these are the salt required, and contain no alkaline quality. But to obtain it in greater purity, dissolve six pounds of pot-ashes in four times their weight of water; filter the lixivium while hot, and make it perfectly clear; then put it into a glass vessel, ready heated and moistened, and suffer it to stand; a dusky crust will soon begin to shoot to the bottom and sides of the glass, and will gradually become thicker and thicker; at length, when no more appears to shoot, pour off the liquor, and there will remain behind a salt like the former, but purer, and in larger quantity; if the remaining lixivium be boiled a little, and set to crystallize again, it will afford a small quantity more of this salt, but after this it will yield no more, whence there seems to be only a certain and determinate quantity of this salt contained in the alkali. If this salt be put into a vessel of rain-water and shook about, it does not dissolve, only the alkali washes off, and the salt remains purer than before; after this it is to be gently dried and kept. Boer. Chem. pt. ii. p. 42.

It is well known among the chemists, that genuine fixed alkaline salts can hardly be crystallized; and though some have produced this salt as a crystallized alkali, the fallacy of the pretext is evident, since this appears on trial to be no alkali at all; and it remains not less difficult than before to crystallize pure alkali, though a salt, different in its nature from it, may be crystallized in a certain quantity from among it.

This vitreous salt never runs spontaneously in the air, nor does it easily dissolve in cold water; when boiled, it requires a large proportion of water to dissolve it, and as soon as cold, it easily separates itself from it again; it is lastingly bitter to the taste, and crackles very much when thrown into the fire; it is neither acid nor alkaline, nor approaches in its nature to any other salt hitherto known, but seems nearest of all others to resemble sandiver. This may suggest a query, whether the fire in producing the fixed alkali, does not at the same time produce this salt from vegetables; and whether, by combining the sand and alkali together in glass-making, the fire does not again separate and throw up this salt in sandiver. Something of this kind seems to be the case, and a close inquiry on these principles may shew us why tartar, in the state of an alkali, does not afford this salt; for tartar proceeds from a subtile liquor, intimately fermented in all its parts. There yet remains the trying of this salt on various bodies, by means of fire, to give a true knowledge of its nature, which is at present too little known. This is to be observed, however, that it differs so much from the alkali in which it is contained, that the careful chemist, before he makes use of that alkali in any nice process or experiment, ought carefully to separate this neutral salt from it. Boerhaave's Chem. part ii. p. 100.

Salt, *Volatile*, a name commonly given to volatile, concrete, alkaline salts, as *volatile sal* Ammoniac, and *volatile salt of hart's*-horn. See also *Volatile Salt of* Amber.

Salts, *Urinous*, a term synonimous with alkaline salt.

Salt *of Steel*, a name given to several combinations of iron with acids; hence Riverius's salt of steel is a martial vitriol, made with iron, vitriolic acid, and spirit of wine.

Salts *microscopically examined*. Mr. Leeuwenhoeck has opened a very extensive field for microscopic observations, in the evaporation of certain fluids, in which salts of various plants, and other substances of the like kind, had been dissolved.

The fixed salts, in general, are said by chemists to admit of no crystallization at all; but this curious observer found, that, on being evaporated in small quantities before the microscope, they each would shoot into extremely minute, but regular crystals, and those often of various forms in the same salt; but that these varieties were only of a certain number, and that no other salt but that to which they belonged had them all in the same regular manner.

The sophistications of salts, too common among our chemists, may be discovered by this means, and many other advantages may be obtained from it, as well as great amusement in the observation of the variety and beauty of the figure.

The most agreeable way of examining these salts, is by the solar microscope; but the most accurate and fittest for making deductions from, is that by the common double microscope. The way is to dissolve a small quantity of salt, of any kind, in water, and add to this about one-fourth part of spirit of wine; this renders the whole a much less fit menstruum for keeping the salt in solution, and consequently it much more readily concretes from among it. A large drop of this liquor is to be laid on the surface of a thin and clear piece of glass, such as may conveniently be laid upon the stand for receiving objects in this microscope: then this glass is to be held till gently heated over a clear fire, and when it begins to evaporate, the glass is to be placed under

the microfcope, and about a third magnifier ufed to examine it. The falts will foon be feen beginning to fhoot, and will form themfelves under the eye into very beautiful figures; fome refembling branches of trees, others ruins and fortifications, and the like; but what are moft to be depended upon, as effential to the falt, are certain little fingle fhoots, refembling cryftals; thefe are determinate in their figure, the others more vague and uncertain. Thefe will always be produced the fame from the fame falt, the others fcarce twice from even the different drops of the fame folution, alike in all refpects. Phil. Tranf. No. 172. p. 1075. See *Table of* MICROSCOPIC *Objects*.

Saw

SAW, SERRA, an inſtrument ſerving to divide into pieces divers ſolid matters, as wood, ſtone, marble, ivory, &c. The ſaw is one of the moſt uſeful machines, in the mechanic arts, ever invented. The fable which is perhaps founded on ſome ſurer tradition, attributes the invention of it to Icarus, who, vying with his father Dædalus, enriched the riſing arts with ſeveral diſcoveries. It is added he took the firſt hint from the ſpine or back-bone of a flat fiſh, ſuch as the ſoal. The ſaw is made of ſteel, with teeth; but thoſe differently filed, and turned, according to the uſe it is deſigned for. There is alſo a kind of ſaws without teeth, uſed in the ſawing of marble, and other ſtones.

The beſt ſaws are of tempered ſteel, ground bright and ſmooth: thoſe of iron are only hammer-hardened: hence, the firſt, beſides their being ſtiffer, are likewiſe found ſmoother, than the laſt. They are known to be well ham-

mered by the ſtiff bending of the blade; and well or evenly ground, by the bending into a bow.

The edge, in which the teeth are, is always thicker than the back, in regard the back is to follow the edge. The teeth are cut and ſharpened by a triangular file; firſt fixing the blade of a ſaw in a whetting block.

When filed, the teeth are to be *ſet*, that is, to be turned alternately aſkew, or out of the right line, to make the wider kerf or fiſſure, that the back may follow the better. This is done by putting an inſtrument, called a *ſaw-wriſt*, between every other two teeth, and giving it a little wrench, which turns one of the teeth a little towards you, and the other a little from you. The teeth are always ſet ranker for coarſe cheap ſtuff, than for hard and fine; becauſe the ranker the tooth is ſet, the more ſtuff is loſt in the kerf; and if the ſtuff be hard, the greater is the labour of ſawing it.

The workmen who make the greateſt uſe of the ſaw, are the ſawyers, carpenters, joiners, eboniſts, ſtone-cutters, carvers, ſculptors, &c. The lapidaries too have their ſaw, as well as the workers in moſaic; but theſe bear little reſemblance to the common ſaws.

But of all mechanics there are none who have ſo many ſaws as the joiners; nor of ſo many different kinds. The chief are as follow:

Pit-ſaw, a large two-handed ſaw, uſed to ſaw timber in pits. It is ſet rank for coarſe ſtuff, ſo as to make a kerf or fiſſure of almoſt a quarter of an inch; but for finer ſtuff it is ſet finer.

Whip-ſaw, which is likewiſe two-handed, uſed to ſaw ſuch large pieces of ſtuff as the hand-ſaw will not eaſily reach.

The *Hand-ſaw* is made for a ſingle man's uſe; of which there are various kinds; as the

Ripping-ſaw, *Tenon-ſaw*, *Saſh-ſaw*: the two latter are ſtiffened by a narrow back of iron, as they are made very thin for fine work.

The *Two-hand*, or *Croſs-cut ſaw*, is much longer, and is uſed by two men.

The *Frame-ſaw* is a thin ſaw ſurrounded by a wooden frame, in which it is ſtretched very tight, to prevent its bending: it is uſed in a pit for cutting deals and vineers.

The *Compaſs-ſaw*, or *Turning-ſaw*, which is very narrow, has its teeth not uſually ſet out of a right line, like the above; but the cutting-edge is made thick, and the back thin, that it may freely be turned in a circular or compaſs-kerf.

The *Hack-ſaw* is made of a ſcythe jagged at the edge, and uſed for cutting off iron bolts.

Sawing

SAWING, the application of the ſaw, in dividing of timber, &c. into boards, &c.

There are wind-mills and water-mills which do the office of ſawing wood, with infinitely more expedition and eaſe than is performed by the hand. They conſiſt of ſeveral parallel ſaws, which are made to riſe and fall perpendicularly, by means of one of the grand principles of motion. A very few hands are here needed, *viz.* only to puſh forward the pieces of timber, which are laid on rollers, or ſuſpended by ropes, in proportion as the ſawing advances. Theſe mills are frequently uſed abroad; and have been alſo introduced in England; but the parliament, in conſideration of this, that they would ſpoil the ſawyers' trade, and ruin great numbers of families, thought fit to ſuppreſs them.

The mechaniſm of a ſawing-mill may be reduced to three principal things; the firſt, that the ſaw be drawn up and down as long as is neceſſary, by a motion communicated by water to the wheel; the ſecond, that the pieces of timber to be cut into boards be advanced by an uniform motion to receive the ſtrokes of the ſaw, for here the wood is to meet the ſaw, and not the ſaw to follow the wood, therefore the motion of the wood and that of the ſaw ought immediately to depend the one on the other: the third, that when the ſaw has cut through the whole length of the piece, the whole machine ſtops of itſelf, and remains immoveable, for fear, leſt having no obſtacle to ſurmount, the force of the water ſhould turn the wheel with too great rapidity, and break ſome part of the machine.

M. Felibien mentions a kind of long ſaws, invented by one Miſſon, inſpector of the marble quarries in the Pyreneans; by means of which ſtones are ſawed even in the rock itſelf, whence they are taken. He adds, that ſome of them were made twenty-three feet long; but does not deſcribe either their form or application: he only ſays, they are of iron, and without teeth.

The common ſawing-mill is ſo well known, as to require ſcarcely any deſcription. The ſaw is made to work vertically, being ſtretched in a wooden frame, which ſlides up and down, within another fixed frame, exactly the ſame as a window ſaſh riſes and falls in its frame: the motion is given to it by a crank placed beneath, and revolving by a wheel and pinion from the water-wheel; a fly-wheel is fixed upon the axis of the crank to equalize the movement, and the pinion is ſo proportioned, that the crank will make three or four turns to one of the water-wheel. The timber is faſtened upon a carriage, which is an horizontal frame, ſliding on the floor of the mill; and being ſufficiently narrow to paſs through the inſide of the vertical or moving ſaw-frame, it will carry the tree through, and ſubject it to the action of the ſaw: the carriage is provided with a rack, which is engaged by the teeth of a pinion, and this gives the means of advancing the carriage when the pinion is turned, which is done by means of a large ratchet-wheel, with a click moved by levers, connected with the ſaw-frame. In this manner, when the ſaw-frame riſes, the click ſlips over a certain number of teeth of the ratchet-wheel, but when it deſcends to make the cut, the click turns the ratchet-wheel round, and advances the wood forwards juſt as much as the ſaw will cut into it during its deſcent. The trees are generally dragged up an inclined plane, through a door at one end of the mill, and being placed upon the carriage, they go through the mill, and are divided by the ſaw into two or more pieces, which are carried forwards, and go out at a door on the oppoſite ſide of the mill, where a boat receives them. Sometimes the ſaw-frame is fitted up with ſeveral ſaws ſtretched parallel to each other, and at ſuch diſtances, that they will divide the whole tree into ſeveral boards of any required thickneſs at one operation.

A great improvement in ſawing-machines has been made by Mr. Brunel, by which they are enabled to cut more timber in a given time, with any given power, and alſo cut much more correctly, and without winding in the ſurfaces which the ſaws divide. A capital mill on this plan has been conſtructed by Mr. Maudſlay for the arſenal at Woolwich; it is driven by a ſteam-engine, which is a pattern of elegance in its appearance, as much as of perfection in its contrivance; the motion is communicated from this to the cranks of the four ſaw-frames, by leather belts, which are here very judiciouſly applied in lieu of cog-wheels, becauſe theſe will ſlip and yield if any thing ſhould get into the movements, but cog-wheels would in a ſimilar caſe break every thing to pieces. Each crank has an independent fly-wheel to regulate its motion, in addition to the great fly-wheel of the ſteam-engine. The vertical or moving frames for the ſaws are made of iron, but the ſides are hollow, and filled up with wood, by which means they are very ſtrong, but of no greater weight than neceſſary. The moſt ingenious part of the contrivance conſiſts in the means of ſtretching all the ſaws in the frame, ſo that they will be exactly parallel to each other, and all ſtrained to an equal degree of tenſion. The ſaws are ſo fitted in the frame, that they can be removed in a few minutes, and a new ſet of ſharp ſaws put in. Each ſaw has a piece of metal rivetted to it at each end, which are formed like hooks. The hook at the lower end of the ſaw is hooked into a proper receſs made in the lower croſs-bar of the ſaw-frame, and the upper hook is engaged with the hook of a ſhackle or link, which hangs upon the upper croſs-bar, and has wedges through it, by means of which it can be drawn tight to ſtrain the ſaw. As there is nothing to determine the parts of the croſs-bars where the hooks of the ſaws ſhall hang upon them, they can be ſet at any required diſtance aſunder; but to retain them, pieces of hard wood are put in between the blades of the ſaw at the upper and lower ends, and the ſpaces being thus filled up, they are bound tight by ſcrews, which are tapped into the ſides of the ſaw-frame. As the tenſion of the different ſaws would be very uncertain, if it depended merely upon driving the wedges of their ſhackles by a hammer, the inventor has applied a very ingenious kind of ſteelyard, to ſtrain each of the ſaws in its turn. It conſiſts of the following parts: a ſtrong axis is extended acroſs the fixed frame, in which the ſaw-frame ſlides, and above the top of this frame; from one ſide of

this axis a lever proceeds, which has a weight fixed at the end, and from the oppofite fide of the axis proceed two fhort levers, which are connected by links with a ftrong crofs-bar, fituated juft over the upper crofs-bar of the faw-frame, when it is at its greateft point of elevation. This fteelyard crofs-bar has a link or fhackle upon it, which can be united by a key with any one of the fhackles upon the upper crofs-bar of the faw-frame, which fhackles are, as before-mentioned, united by their hooks with the upper end of their refpective faws; by this means the lever, with its weight, becomes a fteelyard to draw up any one of the faws with a determinate force, and it can be applied fucceffively to all the different faws. In ufing this apparatus, the band or ftrap of the crank-fhaft is caft off, to ftop the motion of the faw-frame; the crank is turned round, to elevate the frame to the higheft point; two wedges are then put in between the top of the faw-frame and a fixed part of the ftationary frame, and this holds the faw-frame faft whilft the fteelyard is applied, otherwife it would tend to draw up the frame, and ftrain the crank and crank-rod. The fharp faws are now put into the faw-frame, by hooking them upon the lower crofs-bar thereof, and uniting the upper hooks to the fhackles on the upper crofs-bar: the pieces of wood are next put between the faws, according to the gauge of the wood which is intended to be fawn, and bound faft by the fcrews, as before-mentioned. The loaded end of the fteelyard is now lifted up by a rope paffing over a pulley, and the link upon the crofs-bar of the fteelyard is united with the fhackle of one of the faws by means of its keys; then fuffering the fteelyard to defcend, it ftretches the faw: the wedge of the fhackle for the faw is thruft in by the hand as far as it will go, and thus retains the faw at the tenfion to which the fteelyard had ftrained it. The fhackle of the fteelyard is then difengaged from this faw and removed to the next, and thus, in turn, all the faws are equally ftrained, a circumftance which is of great importance, becaufe any faw which is more flack than another will be liable to bend and cut crooked, when the grain of the wood tends to divert it from its true direction.

The carriages of this mill are very admirably contrived to hold the trees firmly, and to fix them in a little time: they are advanced, as the faws cut, by a rack and pinion, with a ratchet-wheel; and the click of the ratchet is moved by means of an excentric wheel, or camm, upon the axis of the crank. There is alfo a contrivance, by which the faw-frame is allowed to ret[r]eat a fmall quantity in its afcent, fo that the teeth of the faw will be quite clear from the wood, when they return, that is, when they afcend, and do not cut. Mr. Brunel has directed the execution of feveral other faw-mills upon the fame principle, particularly a very large one in the dock-yard at Chatham.

Circular Sawing-Machines.—Thefe act by a circular fteel plate, having teeth, like thofe of a pit-faw, cut all round its circumference. This faw is fixed upon an axis, and made to revolve by bands or ftraps with great rapidity. The wood being prefented to it, is cut by a continuous motion; and as this admits of a far greater velocity than can be given to any reciprocating machine, the circular faw cuts a furprifing quantity of wood, not lefs from this circumftance than becaufe it is always in action; whereas the reciprocating faw only cuts in one direction, and all the time occupied in the return is loft. Attempts have been made to make reciprocating faw-frames cut double, by having the different faws reverfed, that is, fome fo placed that they fhall cut in afcending, and the others in defcending; but this did not fucceed, becaufe the faws which do not cut will not allow the others to advance into the wood, at leaft without great friction upon the back of the returning faws.

The circular faw is ufually fixed in a horizontal table, or bench, which has a cleft, through which the faw comes up; the fpindle being fituated under the bench, and acrofs the direction of its length. A fegment or portion of the faw is, therefore, left projecting above the bench; and the piece of wood being laid flat thereupon, it is advanced forwards to the faw, and cut with the greateft facility, and is certain to be cut fquare; but if the fections are required to be at any other angle or bevel, the bench is inclined to fuit it. A long parallel ruler is fixed down upon the bench, and this is capable of being brought nearer or farther from the faw, and thus forms a guide, againft which the piece of wood is held; by this the faw cuts always to the fame width; but the width can be varied at pleafure.

The time of the introduction of this valuable machine is not well afcertained. Circular faws, for cutting the teeth of watch and clock wheels, have been in ufe fince the time of Dr. Hook; but we do not know who firft applied the fame to fawing wood in the large way. Mr. Taylor of Southampton ufed them in his manufactory many years ago; but, we believe, they were moft completely introduced by Mr. George Smart, and have fince become very general for all kinds of purpofes. (See the articles CANTEEN, COMB-CUTTING, and MACHINERY, *Block*, where defcriptions of machines acting with circular faws will be found.) It only remains here to mention an improvement in the mode of mounting them, by Mr. Maudflay. The firft faws, as the moft fimple method, were made with fharp conical points at each end of the fpindle, and thefe were received into conical holes at the ends of fcrews, fitted through the folid frame of the machine; or, otherwife, the points were made upon the ends of the fixed fcrews, and the holes in the ends of the fpindle. In either cafe, the parts were made of hardened fteel, and the moft accurate and convenient circular motion was thus obtained. But if this method is ufed on a large fcale, and with a great velocity, the oil cannot be kept in the fockets, and the friction will then caufe the points of contact to heat: by heating, they expand, and thus increafe the friction and the preffure, fo that the heat is rapidly increafed, till the metal become foft, and will twift off the points. The reafon of the efcape of the oil is, that the centrifugal force induces the oil to mount up the cone, and thus efcape from the point, where it is chiefly wanted. The faw-fpindles made by Mr. Maudflay have double conical fockets, and the oil is introduced by a fmall hole into the fmalleft part of the double cones, where they join; by this means, the centrifugal force draws the oil into the fitting, inftead of throwing it out, as in the other inftance.

An ingenious circular faw was prefented to the Society of Arts, by John Trotter, efq., in 1805, and the Society complimented the inventor with their gold medal. It is called a curvilinear faw, being made concave, that is, like a circular difh or bowl, inftead of a flat circular plate. If this is a fegment of a fphere, the faw will cut fegments of circles, inftead of ftraight lines. This is very ufeful for fellies of wheels, &c.; but by varying the curve of the faw, any required curve of a moderate bend may be cut.

Other circular faws have been made like the trepan ufed by furgeons; the fize, of courfe, being determined by the fize required to be cut. See MACHINERY, *Block*.

A patent has been obtained for a circular faw, or rather a faw with a continuous motion, which confifts of an endlefs fteel band or blade, cut with teeth and extended over two wheels placed at a diftance afunder, juft like the endlefs ftraps which are ufed to communicate motion from one wheel to another. The wood is applied to that part of

the blade which is extended between the two wheels. We have not been informed if it is found to ſucceed in practice; but we fear there would be many difficulties in making ſuch endleſs belts of ſteel.

Screw

SCREW, or SCRUB, *Cochlea*, in *Mechanics*, one of the ſix mechanical powers; chiefly uſed in preſſing or ſqueezing bodies cloſe, though ſometimes alſo in raiſing weights. See MECHANICAL *Powers*.

The ſcrew is a right cylinder, as A B (*Plate* XXXVIII. *Mechanics*, *fig*. 1.) furrowed ſpiral-wiſe; it is generated by the equable motion of a right line F G (*fig*. 2.) around the ſurface of a cylinder; while, at the ſame time, the point I deſcends equably from F towards G. Or, it may be conceived to be made by cutting a piece of paper into the form of an inclined plane, or half-wedge, and then coiling it round a cylinder; ſo that its action depends on the ſame principles as that of an inclined plane. The force tending to turn the ſcrew round its axis may be conſidered as applied horizontally to the baſe of the wedge, and the weight which is to be raiſed as acting vertically on its inclined ſurface: the circumference of the cylinder will repreſent the horizontal length of the wedge; and the diſtance between the threads, meaſured in the direction of the axis, will be its height, provided that the threads be ſingle; conſequently, the forces required for the equilibrium are to each other, as the height of one ſpire to the circumference of the ſcrew. But beſides theſe forces, it is neceſſary that ſome obſtacle be preſent, which may prevent the body, on which the ſcrew acts, from following it in its motion round its axis; otherwiſe there can be no equilibrium. If the furrowed ſurface be convex, the ſcrew is ſaid to be *male*; if concave, it is *female*.

Where motion is to be generated, the male and female ſcrew are always joined; that is, whenever the ſcrew is to be uſed as a ſimple engine, or mechanical power; and when thus fitted together, they are ſometimes called a ſcrew and a nut. The nut acts on the ſcrew with the ſame mechanical power as a ſingle point would do, ſince it only divides the preſſure among the different parts of the ſpire. When joined with an axis in peritrochio, there is no occaſion for a female; but in that caſe it becomes part of a compound engine.

The ſcrew cannot properly be called a ſimple machine, becauſe it is never uſed without the application of a lever, or winch, to aſſiſt in turning it. Sometimes the ſpires of a ſcrew are made to act on the teeth of a wheel, when a very ſlow motion of the wheel, or a very rapid motion of the ſcrew, is required for the purpoſes of the machine.

SCREW, *Doctrine of the*. 1. If, as the compaſs, deſcribed by the power in one turn of the ſcrew, is to the interval or diſtance between any two immediate threads, or ſpiral windings, as B I (meaſured according to the length of the ſcrew), ſo is the weight or reſiſtance to the power; then the power and the reſiſtance will be equivalent one to the other; and, conſequently, the power being increaſed, ſo as to counteract the friction of the ſcrew, which is very conſiderable, will overcome the reſiſtance. For it is evident, that in one turn

of the ſcrew, the weight is ſo much lifted up, or the reſiſtance ſo much moved, or the thing to be preſſed is ſqueezed ſo much cloſer together, as is the diſtance between two immediate ſpirals; and in the ſame time, the power is ſo much moved, as is the compaſs deſcribed by the ſaid power in one turn of the ſcrew. Wherefore the velocity of the weight (or whatſoever anſwers thereto) will be to the velocity of the power, as is the ſaid diſtance between the ſpirals to the compaſs deſcribed by the power, in one revolution or turning round of the ſcrew; ſo that the gaining in power is here recompenſed by the loſs in time.

2. As the diſtance between two threads, B I, is leſs; the power required to overcome the ſaid reſiſtance is leſs; therefore the finer the thread, the eaſier the motion.

3. If the male ſcrew be turned in the female, at reſt, a leſs power will be required to overcome the reſiſtance, as the lever or ſcytala C D (*fig.* 3.) is the longer.

4. The diſtance of the power from the centre of the ſcrew, C D, the diſtance of the two threads I K, and the power to be applied in D, being given, to determine the reſiſtance it will overcome: or, the reſiſtance being given, to find the power neceſſary to overcome it.

Find the periphery of a circle deſcribed by the radius C D; then to the diſtance between the two threads, the periphery juſt found, and the given power; or, to the periphery found, the diſtance of the two threads I K, and the given reſiſtance, find a fourth proportional. This, in the former caſe, will be the reſiſtance that will be overcome by the given power; and, in the latter, the power neceſſary to overcome the reſiſtance.

E. gr. Suppoſe the diſtance between the two threads, 3, the diſtance of the power from the centre of the ſcrew C D, 25, and the power 30 pounds; the periphery of the circle to be deſcribed by the power, will be found 157. Therefore, as 3 : 157 :: 30 : 1570, the weight to which the reſiſtance is equal.

5. The reſiſtance to be overcome by a given power being given; to determine the diameter of the ſcrew, the diſtance of the two threads I K, and the length of the ſcytala, or handle: the diſtance of the threads, and the diameter of the ſcrew, may be aſſumed at pleaſure, if the male be to be turned in the female by a handle. Then, as the given power is to the reſiſtance it is to overcome, ſo is the diſtance of the threads to a fourth number, which will be the periphery to be deſcribed by the handle C D, in a turn of the ſcrew. The ſemidiameter of this periphery, therefore, being ſought, we have the length of the handle C D. But if the female ſcrew be to be turned about the male, without any handle, then the periphery and ſemidiameter found will be very nearly thoſe of the ſcrew required.

E. gr. Suppoſe the weight 6000, the power 100, and the diſtance of the threads 2 lines; for the periphery to be paſſed over by the power, ſay 100 : 6000 :: 2 : 120; the ſemidiameter of which periphery being ⅓d of 120 = 40 lines, will be the length of the handle, if any be uſed; otherwiſe the ſide of the female ſcrew muſt be 40 lines. Mr. Hunter has deſcribed a new method of applying the ſcrew with advantage in particular caſes. Phil. Tranſ. vol. lxxi. part i. p. 58, &c.

A cylindrical ſcrew is bored, and made at the ſame time a tubular ſcrew, with a little difference in the diſtances of the threads, ſo that when it is turned within a fixed nut, it riſes or ſinks a little more or leſs than the internal ſcrew, which perforates it, would riſe or ſink by the action of its own threads; and a weight attached to this internal ſcrew aſcends, in each revolution, only through a ſpace equal to the difference of the height of the two coils. Here the machine is analogous to a very thin wedge, of which the thickneſs is only equal to the difference of the diſtances of the threads, and which of courſe acts with a great mechanical advantage. It might, in ſome caſes, be more convenient to make two cylindrical ſcrews of different kinds, at different parts of the ſame axis, rather than to perforate it. The friction of ſuch machines is, however, a great impediment to their operation.

Screw, *Endleſs.* If a ſcrew be ſo fitted as to turn a dented wheel D F (*fig.* 4.) it is called an *endleſs*, or *perpetual ſcrew*, becauſe it may be turned for ever, without coming at an end. From the ſcheme, it is evident enough, that while the ſcrew turns once round, the wheel only advances the diſtance of one tooth.

Screw, *Doctrine of the Endleſs.* 1. If the power applied to the lever, or handle of an endleſs ſcrew A B, be to the weight, in a ratio compounded of the periphery of the axis of the wheel E H, to the periphery deſcribed by the power in turning the handle, and of the revolutions of the wheel D F, to the revolutions of the ſcrew C B, the power will be equivalent to the weight.

Hence, 1. As the motion of the wheel is exceedingly ſlow, a ſmall power may raiſe a vaſt weight, by means of an endleſs ſcrew; for this reaſon, the great uſe of the endleſs ſcrew is, either where a great weight is to be raiſed through a little ſpace; or, where a very ſlow gentle motion is required. On which account it is very uſeful in clocks and watches.

2. The number of teeth, the diſtance of the power from the centre of the ſcrew A B, the radius of the axis H E, and the power, being given; to find the weight it will raiſe.

Multiply the diſtance of the power from the centre of the ſcrew A B, into the number of teeth: the product is the ſpace of the power paſſed through, in the time the weight paſſes through a ſpace equal to the periphery of the axis. Find a fourth proportional to the radius of the axis, the ſpace of the power now found, and the power. This will be the weight which the power is able to ſuſtain. Thus, if A B = 3, the radius of the axis H E = 1; the power 100 pounds, number of teeth of the wheel D F 48; the weight will be found 14,400; whence it appears, that the endleſs ſcrew exceeds all others in increaſing the force of a power.

A machine for ſhewing the power of the ſcrew, may be contrived in the following manner. Let the wheel C (*fig.* 5.) have a ſcrew *a b* on its axis, working in the teeth of the wheel D, which we may ſuppoſe to be forty-eight in number. It is plain, that for every revolution of the wheel C, and ſcrew *a b*, by the winch A, the wheel D will be moved one tooth by the ſcrew; and, therefore, in forty-eight revolutions of the winch, the wheel D will be once turned round. Then, if the circumference of a circle, deſcribed by the handle of the winch, be equal to the circumference of a groove *e* round the wheel D, the velocity of the handle will be forty-eight times as great as the velocity of any given point in the groove. Conſequently, if a line G goes round the groove *e*, and has a weight of forty-eight pounds hung to it below the pedeſtal E F, a power equal to one pound at the handle will balance and ſupport the weight. To prove this by experiment, let the circumferences of the grooves of the wheels C and D be equal to one another; and then, if a weight H of one pound be ſuſpended by a line going round the groove of the wheel C, it will balance a weight of forty-eight pounds hanging by the line G; and a ſmall addition to the weight H will cauſe it to deſcend, and ſo raiſe up the other weight. If the line G, inſtead of going round the

groove *e* of the wheel D, goes round its axle I, the power of the machine will be as much increaſed, as the circumference of the groove *e* exceeds the circumference of the axle; and if we ſuppoſe it to be ſix times, then one pound at H will balance ſix times 48, or 288 pounds hung to the line on the axle; and hence the power or advantage of this machine will be as 288 to 1; *i. e.* a man, who by his natural ſtrength could lift a hundred weight, will be able to raiſe 288 hundred, or 14$\frac{8}{20}$ ton weight by this engine. Ferguſon's Mech. edit. 4to. p. 44.

Screw, *Archimedes's*, or the *ſpiral pump*, or as it is called in Germany, the *water ſnail*, is a machine for the raiſing of water, firſt invented by Archimedes.

Its ſtructure and uſe will be underſtood by the following deſcription of it. A B C D (*Plate* XIV. *Hydraulics*, *fig.* 11.) is a wheel, which is turned round, according to the order of the letters, by the fall of water E F, which need not be more than three feet. The axle G of the wheel is elevated ſo as to make an angle of about 44°, or between 45° and 60°, with the horizon; and on the top of that axle is a wheel H, which turns ſuch another wheel I of the ſame number of teeth; the axle K of this laſt wheel being parallel to the axle G of the two former wheels. The axle G is cut into a double-threaded ſcrew (as in *fig.* 12.), exactly reſembling the ſcrew on the axis of the fly of a common jack, which muſt be what is called a right-handed ſcrew, like the wood ſcrews, if the firſt wheel turns in the direction A B C D; but it muſt be a left-handed ſcrew, if the ſtream turns the wheel the contrary way; and the ſcrew on the axle G muſt be cut in a contrary way to that on the axle K, becauſe theſe axles turn in contrary directions. Theſe ſcrews muſt be covered cloſe over with boards, like thoſe of a cylindrical caſk; and then they will be ſpiral tubes. Or, they may be made of tubes of ſtiff leather, and wrapt round the axles in ſhallow grooves cut therein, as in *fig.* 13. The lower end of the axle G turns conſtantly in the ſtream that turns the wheel, and the lower ends of the ſpiral tubes are open into the water. So that, as the wheel and axle are turned round, the water riſes in the ſpiral tubes, and runs out at L through the holes M, N, as they come about below the axle. Theſe holes, of which there may be any number, as four or ſix, are in a broad cloſe ring on the top of the axle, into which ring the water is delivered from the upper open ends of the ſcrew tubes, and falls into the open box N. The lower end of the axle K turns on a gudgeon, in the water in N; and the ſpiral tubes in that axle take up the water from N, and deliver it into another ſuch box under the top of K; on which there may be ſuch another wheel as I, to turn a third axle by ſuch a wheel upon it. And in this manner water may be raiſed to any given height, where there is a ſtream ſufficient for that purpoſe to act on the broad float-boards of the firſt wheel. Ferguſon's Mechanics, Supplement, p. 22.

An inſtrument of a ſimilar nature is called by the Germans a water ſcrew; it conſiſts of a cylinder with its ſpiral projections detached from the external cylinder or coating, within which it revolves. This machine might not improperly be conſidered as a pump, but its operation is preciſely ſimilar to that of the ſcrew of Archimedes. It is evident that ſome loſs muſt here be occaſioned by the want of perfect contact between the ſcrew and its cover; in general, at leaſt one-third of the water runs back, and the machine cannot be placed at a greater elevation than 30°; it is alſo very eaſily clogged by accidental impurities of the water; yet it has been found to raiſe more water than the ſcrew of Archimedes, when the lower ends of both are immerſed to a conſiderable depth; ſo that if the height of the ſurface of the water to be raiſed were liable to any great variations, the water ſcrew might be preferable to the ſcrew of Archimedes. *Plate* XIV. *Hydraulics*, *fig.* 14.

When a ſpiral pipe, conſiſting of many convolutions, arranged either in a ſingle plane, or in a cylindrical or conical ſurface, and revolving round a horizontal axis, is connected at one end by a water-tight joint with an aſcending pipe, while the other end receives during each revolution nearly equal quantities of air and water, the machine is called a ſpiral pump. It was invented about 1746, by Andrew Wirtz, a pewterer at Zurich, and it is ſaid to have been uſed with great ſucceſs at Florence and in Ruſſia: it has alſo been employed in this country by lord Stanhope; and I have made trial of it (ſays Dr. Young) for raiſing water to a height of forty feet. The end of the pipe is furniſhed with a ſpoon, containing as much water as will fill half a coil, which enters the pipe a little before the ſpoon has arrived at its higheſt ſituation, the other half remaining full of air, which communicates the preſſure of the column of water to the preceding portion, and in this manner the effect of nearly all the water in the wheel is united, and becomes equivalent to that of the column of water, or of water mixed with air, in the aſcending pipe. The air neareſt the joint is compreſſed into a ſpace much ſmaller than that which it occupied at its entrance, ſo that where the height is conſiderable, it becomes adviſeable to admit a larger portion of air than would naturally fill half the coil, and this leſſens the quantity of water raiſed, but it leſſens alſo the force required to turn the machine. The joint ought to be conical, in order that it may be tightened when it becomes looſe, and the preſſure ought to be removed from it as much as poſſible. The loſs of power, ſuppoſing the machine well conſtructed, ariſes only from the friction of the water on the pipe, and the friction of the wheel on its axis; and where a large quantity of water is to be raiſed to a moderate height, both of theſe reſiſtances may be rendered inconſiderable. But when the height is very great, the length of the ſpiral muſt be much increaſed, ſo that the weight of the pipe becomes extremely cumberſome, and cauſes a great friction on the axis, as well as a ſtrain on the machinery: thus, for a height of 40 feet, Dr. Young found that the wheel required above 100 feet of a pipe which was three quarters of an inch in diameter; and more than one half of the pipe being always full of water, we have to overcome the friction of about 80 feet of ſuch a pipe, which will require 24 times as much exceſs of preſſure to produce a given velocity, as if there were no friction. The centrifugal force of the water in the wheel would alſo materially impede its aſcent if the velocity were conſiderable, ſince it would be always poſſible to turn it ſo rapidly as to throw the whole water back into the ſpoon. The machine which Dr. Young had erected being out of repair, he thought it more eligible to ſubſtitute for it a common forcing pump, than to attempt to make any further improvement in it, under circumſtances ſo unfavourable. But if the wheel with its pipes were entirely made of wood, it might in many caſes ſucceed better: or the pipes might be made of tinned copper, or even of earthenware, which might be cheaper and lighter than lead. See *fig.* 15.

The centrifugal force, which is an impediment to the operation of Wirtz's machines, has ſometimes been employed together with the preſſure of the atmoſphere, as an immediate agent in raiſing water, by means of the rotatory pump. This machine conſiſts of a vertical pipe, cauſed to revolve round its axis, and connected above with a horizontal pipe, which is open at one or at both ends, the whole being furniſhed with proper valves to prevent the eſcape of the water when the machine is at reſt. As ſoon as the rota-

tion becomes fufficiently rapid, the centrifugal force of the water in the horizontal pipe caufes it to be difcharged at the end, its place being fupplied by means of the preffure of the atmofphere on the refervoir below, which forces the water to afcend through the vertical pipe. It has alfo been propofed to turn a machine of this kind by the counter-pref-fure of another portion of water, in the manner of Parent's mill, where there is fall enough to carry it off. This machine may be fo arranged, that, according to theory, little of the force applied may be loft; but it has failed of producing in practice a very advantageous effect. Young's Phil. vol. i. See CENTRIFUGAL *Machine*, and WHEEL.

SCREW, *Bed* or *Barrel*, a powerful machine for lifting heavy bodies; and, when placed againft the gripe of a fhip to be launched, for ftarting her. It confifts of two large *poppets*, or male fcrews, having holes in their heads to admit levers to turn therewith, a *bed* formed of a large oblong piece of elm, with female fcrews near each end to admit the poppets, and a fole of elm plank for the heels of the poppets to work on. When ufed for launching of fhips, the furface of the fole is inclined fo as to ftand fquare to the ftem or gripe.

Hand-fcrews, or *jacks*, double or fingle, are ufed by hand to lift weighty bodies. It confifts of an elm box, containing cogged iron wheels, of increafing powers. The outer one, which moves the others, is put in motion by a winch or handle on the outfide. They are called fingle or double, according to their increafing force.

Serge

SERGE, in *Commerce*, a woollen quilted ſtuff, manufactured on a loom with four treddles, after the manner of rateens, and other ſtuffs that have the whale.

The goodneſs of ſerges is known by the quilting, as that of cloths by the ſpinning.

Of ſerges there are various kinds, denominated either from the different qualities of them, or from the places where they are wrought. The moſt conſiderable is the London ſerge, now highly valued abroad, particularly in France, where a manufacture has been carried on with good ſucceſs, under the title of *ſerge façon de Londres*.

SERGE, *Manufacture of London*. For wool, the longeſt is choſen for the warp, and the ſhorteſt for the woof. Before either kind is uſed, it is firſt ſcoured, by putting it in a copper of liquor, ſomewhat more than lukewarm, compoſed of three parts of fair water and one of urine. After having ſtaid long enough therein for the liquor to diſſolve, and take off the greaſe, &c. it is ſtirred briſkly about with a wooden peel; taken out of the liquor, drained, and waſhed in a running water, dried in the ſhade, beaten with ſticks on a wooden rack, to drive out the coarſer dirt and filth, and then picked clean with the hands. Thus far prepared, it is greaſed with oil of olives, and the longeſt part, deſtined for the warp, is combed with large combs, heated in a little furnace for the purpoſe. To clear off the oil again, the wool is put in a liquor compoſed of hot water, with ſoap melted in it: whence being taken out, wrung, and dried, it is ſpun on the wheel.

As to the ſhorter wool, intended for the woof, it is only carded on the knee with ſmall cards, and then ſpun on the wheel, without being ſcoured of its oil. Note, the thread for the warp is always to be ſpun much finer, and better twiſted than that of the woof.

The wool both for the warp and the woof being ſpun, and the thread divided into ſkains, that of the woof is put on ſpools (unleſs it have been ſpun upon them) fit for the cavity or eye of the ſhuttle; and that for the warp is wound on a kind of wooden bobbins to fit it for warping. When warped it is ſtiffened with a kind of ſize, of which that made of the ſhreds of parchment is held the beſt; and when dry is put on the loom.

When mounted on the loom, the workman raiſing and falling the threads (which are paſſed through a reed), by means of four treddles placed underneath the loom, which he makes to act tranſverſely, equally and alternately, one after another, with his feet, in proportion as the threads are raiſed and lowered, throws the ſhuttle acroſs from one ſide to the other; and each time that the ſhuttle is thrown, and the thread of the woof is croſſed between thoſe of the warp, ſtrikes it with the frame to which the reed is faſtened, through whoſe teeth the threads of the warp paſs; and this ſtroke he repeats twice or thrice, or even more, till he judges the croſſing of the ſerge ſufficiently cloſe: thus he proceeds till the warp is all filled with woof.

The ſerge now taken off the loom is carried to the fuller, who fulls, or ſcours it in the trough of his mill, with a kind of fat earth, called fullers-earth, firſt purged of all ſtones and filth. After three or four hours ſcouring, the fullers-earth is waſhed out in fair water, brought by little and little into the trough, out of which it is taken when all the earth is cleared; then, with a kind of iron pincers, or plyers, they pull off all the knots, ends, ſtraws, &c. ſticking out on the ſurface on either ſide; and then returning it to the fulling trough, where it is worked with water ſomewhat more than lukewarm, with ſoap diſſolved therein for near two hours: it is then waſhed out till ſuch time as the water becomes quite clear, and there be no ſigns of ſoap left; then it is taken out of the trough, the knots, &c. again pulled off, and then put on the tenter to dry, taking care as faſt as it dries to ſtretch it out both in length and breadth till it be brought to its juſt dimenſions. When well dried, it is taken off the tenter, and dyed, ſhorn, and preſſed.

Shaft

SHAFT, in *Building*. The *shaft of a column* is the body of it; thus called from its ſtraightneſs; but by architects more frequently the *fuſt*. See the dimenſions under COLUMN.

SHAFT is alſo uſed for the ſpire of a church-ſteeple; and for the ſhank or tunnel of a chimney.

SHAFT, or *Tunnel-Pit*, is the well through which the ſtuff, excavated from a tunnel, is drawn up to the ſurface.

SHAFT *of a Mine*, is the hollow entrance or paſſage into a mine, ſunk or dug to come at the ore.

In the tin-mines, after this is ſunk about a fathom, they leave a little, long, ſquare place, which is called a *ſhamble*.

Shafts are ſunk ſome ten, ſome twenty fathoms deep into the earth, more or leſs. Of theſe ſhafts, there is the landing or working-ſhaft, where they bring up the work or ore to the ſurface; but if it be worked by a horſe engine or whim, it is called a whim-ſhaft; and where the water is drawn out of the mine, it is indifferently named an engine-ſhaft, or the rod-ſhaft. See MINE and QUARRY.

SHAFT, in *Agriculture*, a name provincially applied to a handle of a tool; as a ſpade, fork, &c.

SHAFTS *of Carts and Waggons*, the parts or poles between which the thill-horſes draw. The manner in which the fore-horſes are attached to theſe ſhafts, when there are more than the thill-horſes in the teams, is a matter of great conſequence; as the weight or preſſure on them is more or leſs, according to its nature, and the way in which it is performed. See THILL-*Horſes* and WAGGON.

SHAFT-*Drain*, that ſort which is effected by carrying a ſort of ſhaft or pit down to the porous ſtratum below, and which is in uſe where a ſuperficial deſcent cannot be had for the collected waters, and an open ſtratum lies beneath the ſubſoil, ready to receive it. A communication between them becomes here of high advantage, as the coſt and attention of raiſing the water by machinery may thereby be avoided. In caſes of this kind, Mr. Marſhall adviſes the drainer to aſcertain the loweſt point of the ſcite to be improved; and there, ſays he, ſink a ſhaft down, and into, the receiving ſtratum, and fill it up to within a few feet of the ſurface, with rough ſtones, the roots of trees, or other open materials; and, on the top of theſe, form a filter, with heath and gravel, or other ſubſtances, that will prevent earthy matter, or water in a foul ſtate, from entering the ſhaft: and to this filter lead the collected waters. And that where the water is collected by the means of covered drains, and where the filter alſo has a covering placed over it, the entire proceſs will be free from external injury; and a work of this kind may remain unimpaired for ages. But even if the waters were collected by open drains, and the filter were ſuffered to remain in a ſtate of neglect, until the ſhaft, in proceſs of time, ſhould become defective, the remedy would be eaſy. Embrace, ſays he, a dry ſeaſon to re-open the ſhaft, and to cleanſe it, and the materials with which it may be filled, from their impurities; and thus reſtore it, at a ſmall expence, to its original ſtate of perfection. It is further ſtated alſo, that if the ſcite of improvement be liable to any other ſurface-water, than what falls on its own area, ſuch water ought to be conducted away from it ſuperficially, by cutting it off at ſuch a height as will gain a ſufficient fall. And that where the quantity of water, which deſcends into it ſubterraneouſly, (or would deſcend, if a free paſſage were opened for it,) ſhould be found to be too copious to be readily diſcharged by a ſhaft-drain, in the manner here propoſed, proper efforts ſhould be uſed to cut off the ſupply, or as much of it as may be, by a perforated trench or otherwiſe, at a ſufficient height to be able to convey it away ſuperficially; and with a ſufficient fall, to prevent its entering the area to be improved; which will thus have only its own ſuperfluous waters to diſcharge by the ſhaft. He is deſirous to clear the way which leads to this valuable improvement, as he is convinced that there are many inſtances in which it might be applied with great profit. Many of the low, flat-lying, moory vallies of Norfolk, from whoſe baſes ſuperficial drains would be difficult to make, have for their ſubſtructures, it is probable, he ſays, inſatiable depths of ſand; and that, in every diſtrict of the iſland, ſuch objects as are proper for this practice may be found.

Sheffield

SHEFFIELD, or *Sheaffield*, in *Geography*, a large and populous market and manufacturing town in the south division of the wapentake of Strafford and Tickhill, liberty of Hallamshire, West Riding of Yorkshire, England, is situated at the distance of 36 miles S. from Leeds, and 162 N.N.W. from London. The origin and remote history of this town are totally unknown. In the 13th century it was noted as a staple for articles of iron manufacture. Chaucer, who wrote in the reign of Edward III., mentions the "Sheffield Whittle" in one of his poems. At that period it was likewise distinguished by a strong castle, which stood at the north-east of the town, and is said to have been built during the sovereignty of Henry III. This castle descended from the Lovetofts to the Nevils, lords Furnival, and passed from them to the Talbots, earls of Shrewsbury, and subsequently to the Howards, dukes of Norfolk, in whose family the lordship of the manor is still vested. During the civil wars between Charles I. and his parliament, Sheffield castle sustained a long siege in the cause of royalty, but eventually surrendered upon honourable terms, on the 10th of August, 1644, and was soon afterwards ordered to be demolished, which seems to have been done most effectually, as scarcely a vestige of it can now be discovered.

Though Sheffield, as already said, was considered as a staple for iron manufactures at a very early period, its trade, for several centuries, was comparatively confined and precarious, and consisted almost entirely in the making of sheath-knives, scissors, sickles, and scythes. About the commencement of the 17th century, an ordinary kind of tobacco-box of iron, and Jews' harps, began to be manufactured here; and in 1625 the master manufacturers were first incorporated by the style of "The Company of Cutlers of Hallamshire." This corporation is governed by a master, elected annually, six searchers, and twenty-four assistants, and is the only body corporate yet existing in Sheffield. It was not, however, till after the year 1750, that this town assumed the rank it now holds in manufacturing opulence. Previously to that period, none of the manufacturers had extended their traffic beyond the limits of Great Britain; but in the same year Mr. Joseph Broadbent opened a direct trade with the continent; and in 1751, the river Don having been rendered navigable to within three miles of the town, that facility was given to exportation, which has since proved so beneficial to its manufacturing interests. Soon afterwards Mr. Thomas Bolsover began to plate brass and copper buttons with silver; and in 1758 the silver plated manufacture was commenced on an extensive scale by Mr. Joseph Hancock, and has subsequently been prosecuted with great advantage by a numerous class of individuals. The opulence and population of the town increased from that time with great rapidity, and soon gave rise to numerous conveniencies and improvements, both useful and ornamental. In 1760, the first stage-coach started from Sheffield for London; and in 1762, the theatre and assembly-room were built by subscription. In 1770, the first bank in Sheffield was opened by Mr. Roebuck; and in 1786, the new market-place was formed, about the same time that Messrs. Proctors erected the first steam-engine grinding-wheel. In 1793, hackney coaches were introduced; and in the same year also was laid the foundation of the General Infirmary. These circumstances are mentioned, because they are calculated to display the progressive benefits resulting from successful industry and ingenuity, the contemplation of which can scarcely fail to excite pleasurable emotions in every breast.

To notice particularly the various articles manufactured at Sheffield of late years, would occupy too considerable a space to admit of the attempt. The two great divisions of them are into cutlery and plated goods, each of which branch out into numerous ramifications. The manufacture of the latter is almost entirely confined to the town, and comprehends a great diversity of articles: such as tea-urns, coffee-pots, tankards, cups, candlesticks, and other pieces of table furniture. The cutlery division embraces the making of edge-tools, combs, cases, buttons, fenders, files, anvils, joiners' tools, lancets, forks, hafts, ink-stands, nails, knives of every description, scissors, scythes, sickles, awl-blades, bellows, &c. to which we shall only further add the refining of steel. Many of these manufactures are carried on in the country, as well as in the town, especially in the villages and hamlets of Attercliffe, Bentsgreen, Brightside, Buttorthwaite, Carbrooke, Darnal, Dyson-Holmes, Dungworth, Ecclesfield, Greenoside, Grimesthorpe, Hallam, Miln-houses, Newfield-Green, Owlerton, Pittsmoor, Stannington, Shiregreen, Upper-Heeley, Wadsley, Woodseats, &c.; all of which are situated within seven miles of Sheffield. Besides the above manufactures, there are in the town and its vicinity several extensive founderies for iron, brass, and white metal.

Sheffield occupies a fine eminence at the confluence of two rivers, the Sheaf, whence the name of the town is derived, and the Don. In former times the houses were entirely built of stone; but for the last century they have been chiefly composed of brick. There are few towns which surpass it in the regularity of its streets, many of them running in a direct line, and displaying a series of uniform and respectable edifices. Sheffield extends about

a mile in length, from north to ſouth, and nearly as much in breadth, from eaſt to weſt. According to the population cenſus of 1811, it contains 7927 houſes, and 35,840 inhabitants, being an increaſe of 4526 perſons ſince 1801, the date of the preceding report, notwithſtanding the retardation its manufacturing proſperity has ſuſtained during that eventful period. According to Goſling's plan of the town, made in 1732, there were 32 ſtreets in Sheffield at that time: in 1771 theſe were increaſed by 25 new ſtreets; and in 1792, ſeventeen additional ſtreets had been made.

Sheffield is not particularly diſtinguiſhed by the ſuperiority of its public buildings, which are rather calculated for purpoſes of utility than for ſhow. The principal of them are the Town-hall, built in 1700, Cutlers'-hall, the General Infirmary, the aſſembly-room, and theatre, and four churches belonging to the eſtabliſhment. Neither the Town-hall nor Cutlers'-hall deſerve attention as architectural productions; but the infirmary and theatre are handſome ſtructures. The former, commenced in 1793, ſtands on the weſt ſide of the town; and in reſpect of ſituation, plan, medical aid, and comfortable treatment, may vie with almoſt any ſimilar inſtitution in Great Britain. The latter, which occupies the ſame building with the aſſembly-room, ſtands in Norfolk-ſtreet. The four churches are Trinity church, St. Paul's, St. James's, and a chapel belonging to the duke of Norfolk's hoſpital. Trinity church, anciently called St. Peter's, is the pariſh church of Sheffield, and appears to have been erected as early as the reign of Henry I. On the ſouth ſide of the chancel is the Shrewſbury chapel, which contains four monuments to the memory of the earls of Shrewſbury of the family of Talbot: and on the north ſide is a monument commemorating judge Jeſſop of Broom-hall, and his lady. At the entrance to the ſame diviſion of the church are depoſited the remains of William Walker, of Darnal, in this pariſh, who is ſaid to have been the executioner of Charles I. Beſides the above churches, Sheffield contains ſeven meeting-houſes for Proteſtant diſſenters, one for Unitarians, two for Methodiſts, one for Quakers, and a Roman Catholic chapel.

The duke of Norfolk's hoſpital, mentioned above, ſtands on the eaſtern bank of the Sheaf. It was founded and endowed in 1670, by Henry, earl of Norwich, and received a conſiderable acceſſion of property by Edward, duke of Norfolk, in 1770. The building conſiſts of two quadrangles, each containing eighteen dwellings, for the accommodation of eighteen men, and the ſame number of women, all of whom receive five ſhillings a-week, with clothing and coals. Here is alſo an hoſpital founded by Mr. Thomas Hollis, a merchant of London, in 1703, for poor cutlers' widows; likewiſe a free grammar-ſchool, and two charity-ſchools; one for boys, and another for girls.

The other objects of a public kind which remain to be noticed are, the military barracks, ſituated at the north-eaſtern extremity of the town; and the bridges thrown over the Sheaf and the Don. That upon the latter river is called Lady's bridge, from a religious houſe, which formerly ſtood near it, and was dedicated to the Virgin Mary. It was built in 1485, but underwent great alterations and improvements in 1762.

Sheffield has two market days, weekly, Tueſday and Saturday; the firſt for corn, &c. and the ſecond for butchers' meat. There are alſo fiſh-markets on Monday and Thurſday, and two annual fairs, one on the firſt Tueſday after Whitſun week, and another on the 28th of November. A new market-place, with extenſive and commodious ſhambles and other conveniencies, was formed and finiſhed here Aug. 31, 1786. Sheffield ſupports a weekly newſpaper, called the "Iris," which is edited by Mr. James Montgomery, the author of "The World before the Flood," and other intereſting poems.

The ſcenery in the vicinity of this town may be characterized as romantic. It is ſurrounded by lofty hills, commanding fine views over a populous and variegated country. At the diſtance of about a mile and a half to the eaſtward, ſtand the ruins of Sheffield manor-houſe, the ancient ſeat of the earls of Shrewſbury, where cardinal Wolſey was ſeized with the diſeaſe which terminated his life about a week afterwards, at the abbey of Leiceſter. Wharncliffe park, the ſeat of the honourable James Archibald Stuart Wortley, ſituated on the river Don, ſix miles to the north-weſt of Sheffield, is equally remarkable for the elegance of its manſion, and the beauty of the ſurrounding grounds. In the neighbourhood of Sheffield are ſome alum mines; and at Wickerſley, near the town, is a quarry, which ſupplies the manufacturers with grind-ſtones for the finer articles of cutlery. Aikin's Deſcription of the Country round Mancheſter, 4to. 1795. Magna Britannia, 4to. 1703. Camden's Britannia, fol. edit. 1789. Beauties of England and Wales, vol. xvi. by John Bigland, 8vo. 1812. Gentleman's Magazine, April and September, 1764.

Shoad

SHOAD, in *Mining*, a term for a train of metalline ſtones mixed with earth, ſometimes lying near the ſurface, ſometimes at conſiderable depths, but always ſerving to the miners as a proof that the load or vein of the metal is thereabout. The deeper the ſhoad lies, the nearer is the vein.

SHOAD-*Stones*, a term uſed by the miners of Cornwall, and other parts of this kingdom, to expreſs ſuch looſe maſſes of ſtone, as are uſually found about the entrances into mines, ſometimes running in a ſtraight courſe, from the load or vein of ore to the ſurface of the earth.

Theſe are ſtones of the common kinds, appearing to have been pieces broken from the ſtrata, or larger maſſes, but they uſually contain mundic or marcaſitic matter, and more or leſs of the ore to be found in the mine. They appear to have been at ſome time rolled about in water, their corners being broken off, and their ſurface ſmoothed and rounded.

The antimony mines in Cornwall are always eaſily diſcovered by the ſhoad-ſtones, theſe uſually lying up to the ſurface, or very nearly ſo; and the matter of the ſtone being a white ſpar, or debaſed cryſtal, in which the native colour of the ore, which is a ſhining blueiſh-black, eaſily diſcovers itſelf in ſtreaks and threads.

Shoad-ſtones are of ſo many kinds, and of ſuch various appearances, that it is not eaſy to deſcribe or know them: but the miners, to whom they are of greateſt uſe in the tracing, or ſearching after new mines, diſtinguiſh them from other ſtones by their weight; for if very ponderous, though they look ever ſo much like common ſtones, there is great reaſon to ſuſpect that they contain ſome metal. Another mark of them is their being ſpungy and porous; this is a ſign of eſpecial uſe in the tin countries, for the tin ſhoad-ſtones are often ſo porous and ſpungy, that they reſemble large bodies thoroughly calcined. There are many other appearances of tin ſhoads, the very hardeſt and firmeſt ſtones often containing this metal.

When the miners, in tracing a ſhoad up hill, meet with ſuch odd ſtones and earths, that they know not well what to make of them, they have recourſe to vanning, that is, they calcine and powder the ſtone, clay, or whatever elſe is ſuppoſed to contain the metal; and then waſhing it in an inſtrument, prepared for that purpoſe, and called a *vanning ſhovel*, they find the earthy matter waſhed away, and of the remainder, the ſtony, or gravelly matter lies behind, and the metalline matter at the point of the ſhovel. If the perſon who performs this operation has any judgment, he eaſily diſcovers not only what the metal is that is contained in the ſhoad, but alſo will make a very probable gueſs at what quantity the mine is likely to yield of it in proportion to the ore. Phil. Tranſ. Nº 69. Price's Mineralogia, p. 124, &c.

Shoe

SHOE, in *Geography*, a ſmall iſland in the Pacific ocean, near the coaſt of Waygoo. S. lat. 0° 1′. E. long. 130° 53′.

SHOE *Indians*, Indians of North America, in an iſland of lake Miſſouri. N. lat. 48° 15′. E. long. 105° 45′.

SHOE, a covering for the foot, uſually of leather.

Its ſtructure, though the object of a particular art, is too popular to need explaining.

Its hiſtory is more obſcure. Bend. Baudoin, a ſhoe-maker by profeſſion, has a learned treatiſe of the ancient ſhoe, "De Solea Veterum," where the origin, matter, form, &c. thereof, are particularly inquired into.

Baudoin maintains, that God, in giving Adam ſkins of beaſts to clothe him, did not leave him to go bare-footed, but gave him ſhoes of the ſame matter; that, after raw ſkins, men came to make their ſhoes of ruſhes, broom, paper, flax, ſilk, wood, iron, ſilver, and gold; ſo different has their matter been. Nor was their form more ſtable, with regard either to the ſhape, colour, or ornaments; they have been ſquare, high, low, long, and quite even, cut, carved, &c. Pliny, lib. vii. c. 56, tells us, that one Tychius, of Bœotia, was the firſt who uſed ſhoes.

M. Nilant, in his remarks on Baudoin, obſerves, that he quotes Xenophon wrongly, to ſhew that even in his time they ſtill wore ſhoes of raw ſkins.

Xenophon relates, that the ten thouſand Greeks, who had followed the young Cyrus, wanting ſhoes in their retreat, were forced to cover their feet with raw ſkins, which occaſioned them great inconveniencies.

Nilant will not even allow, that the ſhoes of the country people, called *carbatinæ*, and *peroneæ*, were of crude ſkin, without any preparation.

The patricians, among the Romans, wore an ivory creſcent on their ſhoes: Heliogabalus had his ſhoes covered over with a very white linen, in conformity to the prieſts of the ſun, for whom he profeſſed a very high veneration; this kind of ſhoe was called ὐδῶ, *udo*, or *odo*. Caligula wore ſhoes enriched with precious ſtones. The Indians, like the Egyptians, wore ſhoes made of the bark of the papyrus. The Turks always put off their ſhoes, and leave them at the doors of the moſques.

SHOES *made by rivetting inſtead of ſewing.* A patent was taken out for this invention in 1809, by Mr. David Mead Randolph, an American. In his ſpecification, he deſcribes that the rivetting which he propoſes to ſubſtitute for ſewing, is only applicable to the ſoles and heels of boots or ſhoes, all the other parts being made in the uſual manner. The *laſt* which is uſed for this method is the only implement which demands a particular deſcription. It is firſt made in wood, of the ſame figure as the common laſt, and adjuſted in the uſual manner to the ſize and ſhape of the ſhoe which is intended to be made or put together upon it. The lower part or ſole of the laſt is then covered with a plate of iron or ſteel, about the ſame thickneſs as a ſtout ſole leather: this plate, being formed to the exact ſhape which is deſired, is faſtened down upon the wood by ſcrews or rivets. The iron plate has three circular holes made through it, one at the toe, another about half way between the toe and the heel, and a third at the heel: the holes are about an inch in diameter, and being filled up with wooden plugs, and cut down even with the ſurface of the iron, they will admit the points of temporary nails to be driven through the leather ſole to penetrate into the wood, and fix the ſole upon the laſt whilſt the work goes on.

The making of the ſhoe is conducted in the uſual manner, until it is ready for putting on the laſt. To do this, the inner ſole is put upon the iron ſole of the laſt; then the upper-leathers are put upon the oppoſite part, and the edges of the leather are turned down over the edges of the inner ſole: the outer ſole is then applied over the turning-down, and faſtened in a temporary manner upon the laſt, by driving one or two nails, through both ſoles, into the wooden plugs before mentioned, which fill up the holes in the iron face of the laſt. Now, to unite the two ſoles to the upper-leathers, holes are pierced all round the edges of the ſole, and ſmall nails are driven in, which are of ſufficient length to penetrate through the ſole and the turning-in of the upper-leathers, and alſo through the inner ſole, ſo as to reach the metal face of the laſt, and being forcibly driven, their points will be turned by the iron, ſo as to clench withinſide, or rivet through the leather, and ſerve inſtead of the ſewing or ſtitching commonly employed to unite the ſole to the upper-leathers.

Shoes, *Machines for making.* These are the invention of Mr. Brunel, of whose mechanical genius we have had frequent occasion to speak in this work. He has lately established at Battersea an extensive manufactory of shoes, chiefly intended to supply the army, where all the operations are performed by the aid of machines, which act with such facility, that they can be managed by the invalid soldiers of Chelsea Hospital, who are the only workmen employed, and most of them disabled by wounds, or the loss of their legs, from any other employment.

The shoes made by these machines are different from the common shoes, in the circumstance of the sole being united to the upper-leathers by a number of small rivets instead of sewing, in the same manner as those we have mentioned in the preceding article. To facilitate the description we intend to give of the machines, we shall first describe the structure of one of these shoes. Its upper-leathers are the same as any other shoes, and consist of three pieces; *viz.* the vamp, or part which covers the upper part of the foot, and the two quarters which surround the heel, and are sewed together behind it; they are also sewed to the vamp at about the middle of the length of the shoe. The sole part of the shoe is composed of the real or lower sole, with its welt, the heel, and the inner or upper sole.

The lower sole has an additional border, which is called the runner, or welt, fixed upon its upper side, all round the edge, by a row of rivets, so that it makes a double thickness to the sole towards the edge; but this additional piece is only of small width from the outside of the sole inwards, and gradually diminishes away in thickness to nothing, as it recedes from the edge of the sole, so that the middle part of the sole is only of the same thickness as the single leather. The upper-leathers are made sufficiently large to turn in, all round, beneath the foot, under the edge of the inner sole, for about three-quarters of an inch wide, and the outer sole, reinforced by the welt, is applied beneath, so that the turning-in is included between the two soles; that is, it is included between the edge of the inner sole and the welt, or extra thickness which surrounds the lower sole. To hold the shoe together, a row of rivets is put through the sole, all round the edge, and they are of sufficient length to pass through all the four thicknesses, *viz.* the lower sole, the welt, the upper-leathers, (where they are turned in,) and also through the inner sole; and these rivets being made fast, unite the parts of the shoe together in a much firmer manner than sewing. The rivets have no heads, but are made tapering, and the largest ends are on the outside of the sole, which prevents them from drawing through; and at the same time, the strength of the rivetting will not be materially impaired by the gradual wearing away of the sole leather.

These rivets prevent the wear in a very great degree, and for this reason there is a greater number of rivets put into the sole than merely those which hold the shoe together. The different nails are, first, the *short nails*, or rivets, which only penetrate through the single thickness of the lower sole; these are arranged in parallel rows across the tread of the foot, that is, about two-thirds of the length from the heel; there is likewise a double row of short nails, which is carried round parallel to the outline of the toe, at about three-quarters of an inch from the edge, and extends as far as the middle of the foot. Next, the *tacking nails*, which are of a sufficient length to reach through both the sole and the welt, and thus fix the two together: of these, there is a row all round the edge of the foot, nearer to the edge than the row of short nails before mentioned. Lastly, the *long nails*, which, as before described, fasten the shoe together: these form also a complete row round the edge of the whole shoe, and nearer to the edge than any of the preceding rows. The heel is also fastened on by a row of long nails round its circumference. The heads or thick ends of all these nails appear on the lower surface of the sole, and all contribute to preserve the leather from wearing. We shall now proceed to a description of the ingenious instruments and machines used in this manufactory, beginning with those for

Cutting out the Leather.—This is performed by stamps, each of which is an iron frame or ring, bent to the size and figure of the sole, or other part to be cut out by it: one edge of the frame is edged with steel, and ground sharp, so that it will cut the leather: the sharp edge of this frame being placed upon the skin, and struck with a mallet, will cut out a piece from the skin, which is exactly of the same size as the interior opening of the frame. The leather for the soles is first softened, by soaking it in water; the skin is then spread out on a block or table of lead about two feet long and eighteen inches wide, and the stamp or knife for the soles is placed upon the skin in the most advantageous position to cut out the piece; then two or three blows upon the top of the knife with a beetle or large wooden mallet, forces its edge through the leather, and cuts out the piece, which remains in the opening of the knife, but being taken out another is cut in a similar manner.

A knife of this kind is provided for all the pieces which are used to form the shoe, and they are called after the names of the respective pieces, which are as follow: 1. The sole, which is not cut out the full size for the sole of the shoe, but wants a piece at the heel. 2. The sole-piece is a semicircle, to be joined to the sole to make up the heel. 3 The heel: these two last pieces are cut out of the small pieces, or scraps of leather. 4. The runner, or welt, which is applied upon the sole, all round the edge, to make the extra thickness where the upper-leather is to be joined to the sole. All these parts are cut out from the strong hides. 5. The inner sole. The upper-leathers are, 6, the vamp, or part which covers the toes and upper part of the foot; 7 and 8, the right and left quarters, which surround the heel, and are sewed to the vamp, being also sewed together behind the heel.

All these parts, except the welts, are cut out by knives of the above description, there being a set of knives for every different-sized shoe which is made in the manufactory. For cutting out the inner soles, the knife is fixed horizontally, with its edge upwards, beneath a heavy cast-iron lever, which moves on a centre pin, supported in the same framing which sustains the knife. The lever has a plate of lead attached to it near the centre, so that when it is brought down horizontally the lead will descend upon the knife, the edge of which being imprinted into the lead, will cut through the leather which is previously spread upon the knife. To use this cutting-out machine, the sole is first cut out roughly from the skin by a common cutting-knife round a wooden pattern, and the lever being lifted up nearly to a vertical position, the rough sole is laid fairly upon the edge of the knife; then, by letting fall the lever, its weight, and the leverage upon the plate of lead, causes a sufficient pressure upon the leather to force it upon the edge of the knife, and cut it to the exact shape required. The lever is guided in its descent, to ensure that its lead shall fall precisely upon the knife.

Immediately after the soles are cut out, they are stamped on the grain-side of the leather with a number which denotes the size of the shoe to which they belong. The stamp is engraved on the face of a small hammer, so that one blow makes the desired mark. The heels and other parts are also

marked, that the workman may make no miſtakes in putting the ſhoes together.

The leather for the welts is cut into ſtrips of about an inch wide: for this purpoſe, the piece is ſpread on a flat table about two feet ſquare, the ſurface of which is covered with ſmall iron rulers the width of the intended ſtrips, and ſcrewed down upon the wooden table, leaving between them ſufficient ſpaces to admit the point of a knife. Several ſmall pins project up from theſe iron rulers to penetrate the leather and hold it faſt. To confine the leather down whilſt it is cut, a frame of iron is fixed to the table by hinges at one end, ſo as to fold down horizontally upon the leather, and the frame is covered all over with ſimilar rulers, the intervals between them correſponding exactly with thoſe between the rulers on the table. The cutting is performed by a hooked knife, fixed into a long handle. The workman holds down the frame upon the leather, and introducing the hooked point of the knife between the bars, draws it towards him; this cuts through the leather, and he repeats it at every interval between the rulers, and thus divides the whole leather into ſlips of the ſame breadth as the rulers.

To prepare theſe ſlips for uſe, each one is ſplit lengthways into two other ſlips, by an oblique cut along the middle of it; thus producing two ſlips, which have bevelled or feathered edges, ſimilar to a ruler for drawing. The ſplitting of the ſtrips is performed by a very complete machine, conſiſting of a pair of braſs rollers, one of which is turned by a winch, and the other receives its motion from it by means of a pair of equal cog-wheels, one wheel being fixed upon the ends of each of the rollers. The rollers are mounted one above the other in an iron frame, in a ſimilar manner to thoſe uſed for laminating: the lower one has a groove formed round it, which is of a proper ſize to receive the ſtrip of leather before it is divided, and the preſſure of the upper roller compreſſes it into the groove. A guide, conſiſting of an iron ſtem, with a ſquare hole through it, is fixed up before or in front of the rollers, to conduct the leather into the groove; and on the oppoſite ſide, or behind the rollers, is a ſtem, or ſtandard, which receives a cylindrical ſteel pin, and holds it faſt in an horizontal poſition, in the direction in which the ſtrip of leather will move when it comes through the rollers. The end of this ſteel pin is flattened and ground to a fine ſharp edge, like that of a chiſſel, and preſenting itſelf to the end of the ſtrip of leather as it is paſſed through the rollers, will evidently divide the ſtrip longitudinally into two pieces, when the leather is forced forwards againſt the edge of the cutter by the motion of the rollers. This edge is placed obliquely to the axis of the rollers (or to the ſurface of the leather which paſſes between them), and therefore will divide it by an oblique cut, ſo as to produce two narrow feather-edged pieces from each ſtrip. The preſſure of the rollers upon the leather tends to conſolidate its texture, and ſupply the place of hammering.

Preparation of the Soles.—The leather is hardened by paſſing it between rollers, to produce the ſame effect as hammering does in the ordinary method of ſhoe-making. The rollers uſed for this purpoſe are made of braſs, about five inches diameter, and as much in length; they are mounted in the uſual kind of frame, except that inſtead of ſcrews to hold down the upper roller, and regulate its diſtance from the lower one, two plain cylindric pins are inſerted into the holes which uſually receive the ſcrews, and theſe pins have a ſtrong lever bearing upon their upper ends, to preſs the upper roller down upon the lower, by the action of a weight at the extremity of the lever. Theſe pins are only about four inches diſtant from the centre or fulcrum of the lever, and the weight (of about 100 pounds) is at a diſtance of four feet from the centre, it therefore preſſes down the upper roller upon the lower, with a force of nearly 1200 pounds. The lower roller has a cog-wheel upon the extremity of its ſpindle, which is moved by a pinion upon the end of an axis turned by a winch; one man turns this winch and another puts the ſoles between the rollers. Two ſoles are preſented together, being laid one upon the other, with the fleſh ſides of the leather towards each other, and an iron plate is placed between them, which is made thick in the middle, and diminiſhes every way to the edges, where it is thin. The grain or hair ſide of the leather of the two ſoles is outſide, ſo as to be in contact with the rollers when the ſoles are preſented to the machine which draws them in; and when they have nearly paſſed through, the man who turns the winch reverſes the motion, and rolls them back again, then forwards, and ſo on for four or five times, in the ſame manner as the motion for mangling linen. After this operation the leather becomes hard and ſolid, and much reduced in thickneſs, particularly at the middle part.

The heels being ſo ſmall cannot conveniently be rolled; but to produce the ſame effect they are ſtamped in a fly-preſs: for this purpoſe, a heel-piece is put into a ſmall box or cell of caſt-iron, of a proper ſhape to receive it, and a thick plate, which is fitted to the box, being laid upon it, the whole is put beneath the ſcrew of the preſs, one blow of which is ſufficient to preſs the iron plate upon the leather, with a force which will render it hard and ſolid.

The ſole is made complete by joining to it the ſmall ſemicircular piece at the heel; for this purpoſe, the parts which are to be joined together are cut bevelled, ſo that they will overlap without increaſing the thickneſs, and then three or four nails are driven through the bevelled parts, to hold them together. To cut the joints bevelled, a ſimple preſs is uſed; the ſole is laid flat upon the edge of the bench, and a piece of iron is preſſed down upon it by a lever, upon which the workman leans his elbow. The edge of the bench is bevelled, and faced with iron, and this, together with the upper piece of iron, guides the knife, ſo that it will cut the joint bevelled: the heel-piece is then cut in the ſame manner, but reverſed.

Application of the ſhort Nails.—The leather for the ſole is next inlaid with ſhort copper or iron nails, which are put through holes in the leather, in the broad part of the foot, where the greateſt wear will take place; and there is alſo a double row of ſimilar rivets, inlaid round the toe part, at about three-quarters of an inch within the edge of the ſole. The holes for theſe nails are firſt punched in the leather of the ſole by a punching machine, and then a ſecond machine cuts the nails, and inſerts them into the holes.

The *punching machine* is moved by the foot of the workman, who is ſeated before a ſmall ſemicircular table of caſt iron, on which he places the leather. This table is ſupported by a ſtrong column, riſing from the floor to a height of about two feet above the table, which is joined to the column by a projecting bracket, ſo that the column is on the oppoſite ſide to that where the workman is ſeated. The upper part of the column has two arms, projecting forwards from it towards the workman, and extending over the table; at their extremities they are formed into ſockets, to ſuſtain a ſquare iron rod or perpendicular ſlider, which at the lower end has the piercer or awl ſcrewed into it: one of the ſockets guides the upper part of the ſlider, and the other the lower part, ſo that it has a freedom of motion in a perpendicular direction, but no other. The ſlider is cauſed to deſcend by means of a treadle moving on a centre pin, attached to the foot of the iron column, beneath the bench; from this treadle an iron rod aſcends through a hole in the

bench (and also through holes in the arms, which project from the column to sustain the slider), and at the upper end this rod is connected with a lever, which moves on a joint at the upper end of the iron column, whilst the extreme end of the lever is connected with the top of the perpendicular slider. By this arrangement it is clear, that the foot, being pressed upon the treadle, will communicate motion by the iron rod and upper lever to the slider and piercer, and force its point through the leather, which is placed upon the small iron table. A short lever and counterpoise are provided to raise up the slider again the instant the pressure is removed. To prevent the piercer striking upon the iron of the table, and breaking the point, a screw is inserted in a piece projecting from the slider, and its point in descending comes to rest upon the upper of the two arms which sustain the slider, and thus stops the descent of the slider at the proper place.

The piece of leather for the sole is fixed upon a pattern made of iron plate, cut to the same size and shape as the sole, which is united to it by two sharp gauge pins, which are fixed in the pattern, one at the middle of the tread, and the other in the centre of the heel; and these pins project so far, that they will just penetrate through the leather, to hold it fast against the pattern, which is perforated with all the holes which are intended to be pierced in the sole. The leather is applied upon the pattern, and struck with a mallet, so as to force the gauge pins into the leather, and unite the s le and the pattern together; the pattern is then laid flat upon the table of the machine, with the leather uppermost, and is brought beneath the joint of the piercer, so that it will penetrate in the desired place. To ascertain this place, a small stud or pin is inserted into a hole in the table, in the exact spot where the point of the piercer descends; the stud projects a little above the surface of the table, but is only held up by a spring, so that it can easily be pressed down. The pattern being placed so that any of the holes therein receive the point of the stud, it is evident that when the pressure of the foot makes the piercer descend, its point will make a puncture in the leather which is fastened upon the pattern, which puncture will be opposite to the hole in the pattern; and though it perforates the leather quite through the thickness, the point of the piercer cannot be blunted against the iron, because it is received in the hole in the pattern, and the stud descends by the pressure, so that the pattern will lie quite flat upon the surface of the table. In this manner the workman pierces any number of holes in the leather, placing it beneath the point of the piercer by the aid of the pattern, and then pressing the foot to bring the point down and pierce the hole. As soon as the piercer rises, he removes the pattern to another hole, and so on. A small piece of iron is fixed just above the leather, which prevents its being lifted up, and following the piercer when it rises. The piercer passes through a hole in this piece.

Nailing Machine for the short Nails.—The sole being thus pierced with holes, the short nails are put into it by a very curious machine, which at the same time forms the nails, by cutting them off from the end of a strip of iron or copper, of the same breadth as the length of the intended nails.

The sole is presented to the machine by laying it upon a small table, similar to the last machine, and is directed by means of the same pattern; so that each of the holes in the leather will be successively brought beneath the point of a blunt piercer, which descends by the action of a treadle. In the upper part of the machine is a pair of shears, to cut the nails: they consist of a lever, loaded at the extremity with a weight, and connected with the treadle, so that the end of the lever is lifted up when the treadle is depressed by the foot. Near the centre of this lever is a cutter, which is fixed to it, and moves with it. Another cutter is supported by the frame, so as to be stationary, and in the proper situation to come in contact with the edge of the moving cutter, when the end of the lever is lifted up. The cutters act in a manner similar to a pair of shears, to cut off a small piece from across the end of a slip of iron, which is introduced between the cutters. This piece forms the nail or rivet, which is to be put into the hole in the leather; and immediately after it is cut, it falls into a tube, by which it is conducted down to a small cell or tube, situated immediately over the leather. In this the nail stands perpendicular, and ready, when the piercer descends, to be forced down into the hole in the leather; because the cell which receives the nail is exactly beneath the point of the piercer, so as to hold it perpendicularly in the proper situation. The workman is seated before the machine, and with his right hand directs the sole, with its pattern beneath the piercer, in the same manner as before described. In his left hand he holds the strip of iron or copper which is to make the nails; and he introduces the end of it through a small hole, which conducts to the cutters, pushing it forward with a gentle force: this causes the end of the strip to enter between the cutters, when the shears are open. Then adjusting the sole by the pattern, so that one of the holes in the leather will be beneath the nail contained in the cell, he presses down the treadle: this forces the nail down from the cell into the leather, by the descent of the piercer, and at the same time closes the shears, and cuts off a nail across the end of the strip. The nail immediately descends by the tube into the cell, where it places itself perpendicularly, and ready to be put in its place in its turn. Thus the machine, at every stroke, cuts a fresh nail to supply the place of that which it puts in the leather by the same stroke. The strip of copper is turned over every time, to form the nails alternately head and point.

When all the nails are put in, they are battered down with a hammer; and as they are but very little longer than the thickness of the sole, this reduces them to an even surface.

Application of the Welt to the Sole.—The welt, or runner, is a narrow slip of leather applied upon the sole, round its edge, to make the sole of a double thickness round the edge, where the upper leather joins to the sole, although the sole is only single within. The welt is made from the feather-edged slips which we have before mentioned, and is fastened to the sole by tacking nails of sufficient length to pass through both the sole and the welt. These nails are arranged all round the circumference of the sole, and the holes are first pierced through the sole by the punching machine, which we have before described, but by a different pattern of iron, which is attached to the sole by its two gauge pins entering the same holes which were made through the leather in the first operation. This pattern is pierced with a row of holes all round the circumference, which are arranged within the former row of rivets, or farther from the edge of the sole; but around the toe and tread of the foot, for half its length, the holes are in double number, or at half the distance that they are in the heel part. This pattern being used in the same manner as before described, the punching machine pierces the sole with holes, exactly corresponding to it; which holes are filled with tacking nails in a separate machine, something similar to the nailing machine before described. But as the nails are longer, it would be too laborious to cut them by the same motion; the nails are, therefore, cut by a machine made on purpose, and applied to the leather by

The nailing Machine for long Nails.—This is made exactly the same as the punching machine before described, but with additional apparatus to supply the nails, and put them into the holes. Thus it has a vertical column, with a table and two projecting arms to support the perpendicular slider, which is caused to descend when the foot is applied upon the treadle, and to re-ascend by the action of the counter-weight. The piercer at the lower end is not sharp-pointed, not being intended to penetrate the leather, but only to force the nails into the holes previously pierced by the preceding operation. The additional parts are as follow: a circular plate, or wheel of brass, about nine inches diameter, and of a thickness nearly equal to the length of the nails; it is perforated with a great number of holes, to contain the same number of nails; the holes being made round its circumference, as close together as convenient, and arranged in four circles, one within the other. The interior space within the circles is formed with six arms, like a wheel; and in the centre is a hole, which fits loosely upon an upright centre pin, standing in the centre of a small circular table, which is fixed sideways to the upper of the two arms, which, as before mentioned, project from the vertical column of the machine, and sustain the upper end of the perpendicular slider. Upon this circular table the wheel is supported in a horizontal position, at the height of 18 or 20 inches above the table on which the leather is placed, and with liberty to turn upon its centre pin. The wheel is filled with nails when it is used, one being put into every hole of its circumference, with the points downwards; and the holes are sufficiently large to let the nails drop through the wheel, except when their points rest upon the circular table which supports the wheel. At one part of the circumference of this table an opening is cut through it, and a small tube descends from it, to conduct a nail down to the point of the piercer. The motion of the wheel upon its centre brings the nails successively over the opening or mouth of the tube; and therefore each nail, in its turn, drops by its weight through the hole in the wheel into the tube, which is made so small, that the nail must descend with its point downwards, and fall into a small cell, so situated that the nail will stand exactly beneath the point of the piercer, when the same is at its highest position. But when the piercer is depressed by the action of the treadle, its point will act upon the head of the nail, and force it down through the cell into the leather placed upon the table of the machine; the hole in the leather having been previously pierced by the punching machine. The cell which receives the nail is very ingeniously contrived to hold it in a perpendicular direction, beneath the end of the piercer. It is situated immediately above the leather, and is conical within, so that the nail drops down into it until it becomes fixed fast; but when the nail is to be forced down by the piercer, the cell opens in two halves, being formed by notches in two pieces of steel, which are only held together by being screwed together at one end, and are made so thin as to spring together, and form a cell for the reception of the nail, although they will readily separate when the piercer forces down the nail. It is during the ascent of the piercer that another nail is dropped down from the wheel through the tube, and received into the cell, whilst its two halves are still kept open by the piercer; or rather as the piercer at this moment occupies the interior of the cell, the nail is received in the space, or open joint, at which the two halves of the cell separate, so that the nail lies close by the side of the piercer. But when the piercer has risen up completely out of the cell, its two halves spring together, and the joint in which the nail is placed being formed with faces inclining inwards, they throw the nail into the cell itself, in which it drops down till it sticks fast; because, as before stated, the cell is smaller at the bottom; and in this situation the nail is certain to be held perpendicular, with its head under the point of the piercer.

To turn the wheel round, so as to supply a fresh nail every time that one has been put into the leather, the edge of the wheel is cut into serrated or sloping teeth; the number of teeth being equal to the number of holes made in each of the four circles to contain the nails. A small detent or click takes into these teeth by a hook, so that it will turn the wheel when moved in one direction, but slide over the teeth when moved in the other direction. The click is jointed to a short lever, fixed upon the upper end of an upright axis, which passes down through the two projecting arms of the main column, so as to be very near the perpendicular slider; and a short lever, fixed to this axis, bears, by the action of a spring, against a wedge fixed to the slider. The action of this mechanism is to turn the wheel round one tooth at a time: thus, when the slider descends, its wedge forces the end of the short lever farther away from it; this movement is communicated by the upright axis and upper lever to the click, which slides over the sloping sides of the teeth of the wheel; but on the re-ascent of the slider, the wedge allows the lever and click to return by the action of a spring, and the hook of the click, having caught a tooth of the wheel, will turn the wheel round the space of one tooth. In this manner, at every descent of the slider the click engages a fresh tooth of the wheel; and at every ascent, the wheel is turned round upon its centre pin; the weight of the wheel, resting upon the flat circular table, being sufficient to retain it as it is placed.

The nailing machine acts with the same rapidity as the other machines, to put a nail into every one of the holes previously made; and for this purpose the leather is kept upon the same pattern by which those holes were pierced, not only for the purpose of placing the leather so that the nails shall be inserted into those holes, but that the thickness of the pattern may allow the nails to penetrate and project through the leather on the under side. When the nails are all put in, they are beat down with a hammer, to drive all the heads to a level with the surface. The leather is then separated from the pattern, and put into a frame called

The welting Stand.—This machine is a small square table of cast-iron, fixed on the top of a pedestal, in which it is capable of turning round, for the convenience of the workman, and to enable him to work at the different sides, as he remains seated before the table. An iron frame is connected with the table by hinges at one side, so that it can be lifted up or turned down, to lie flat upon the surface of the table; and in this situation it can be fastened down by means of a simple clamp. This frame is intended to hold fast the leather which is placed beneath the frame: the interior opening of the iron frame is nearly of the same size and shape as the sole of the shoe. The sole is placed flat upon the table, in the proper position, which is determined by two gauge pins fixed into the table, and entering the holes made in the sole; then the iron frame being turned down upon the leather, will inclose the sole as it were with an iron hoop, or raised border, all round the edge; and the frame being clamped fast down, the sole is confined, as if lying in the bottom of a cell of iron, of the same figure as itself, and with the nail points projecting upwards from the sole. In this frame the welt is applied, by laying the strip of leather upon the edge of the sole in contact with the inside of the iron frame, and bending it to follow the curves of the outline of the sole. As fast as any part of the length of the

ftrip is fettled to its pofition, it is attached to the fole by ftriking it down with a mallet upon the points of the nails. The thin or feathered edge of the ftrip of leather is put infide, fo that the edge of the fole, for about the breadth of half an inch, is of a double thicknefs; but within this, the extra thicknefs diminifhes away to nothing, leaving only the thicknefs of the fole. The ends of the ftrip of leather which compofe the welt, where they join and complete the circuit of the fole, are cut floping, fo as to lap over each other, and make a joint, without any increafe of thicknefs, or apparent divifion. When the fole is taken out of this frame, the welt and fole are beat well down together, to make a good joint; it is then carried to the cutting prefs, in which the edge or outline of the fole and welt are cut fmooth, and to the fame fize; becaufe, as the frame of the welting machine muft be rather lefs than the fole, in order that the frame may bear upon the edges of the fole all round, and thus hold it faft, the welt, which is moulded or bent round within the frame, will be a fmall quantity lefs all round than the fole. To guide the knife in cutting round the edge of the fole, it is confined between two iron patterns, which are made exactly to the fize to which the edge is to be pared. They are attached to the fole by two gauge pins, fixed into one of the plates, and paffing through the holes in the fole, project far enough on the oppofite fide for the other plate to be faftened on, in its required pofition, by two holes which receive the ends of the pins.

The *cutting-prefs* very much refembles a common lathe: a horizontal fpindle is fupported in a frame, confifting of two ftandards, erected from a horizontal plate, to fuftain the fpindle, which paffes through a collar in one of thefe ftandards, and projects fome inches beyond it, having at the extremity a piece of wood flat on the furface, and of the fame fhape as the fole. Againft this flat furface the two iron plates, with the fole between, are placed, and they are forcibly preffed together by the action of a fcrew, fitted into a third iron ftandard, erected from the fame horizontal plate, and preffing by means of a lever upon the iron plates exactly oppofite the end of the fpindle. This preffure caufes the fpindle to retreat a fmall quantity in the direction of its length, and then a flat circular plate, fixed upon the fpindle, (in the fame fituation as the pulley of a common lathe,) is made to prefs againft a fimilar flat plate, which is faftened to the frame, and therefore cannot turn round. By the friction between thefe two furfaces, the fpindle becomes immoveable, and the prefs holds the fole firm, whilft the workman, who is feated before the machine, cuts all round the edge with a drawing-knife, which is made fharp in the middle, and is worked with both hands by having a handle at each end. When he has with this tool pared down that part of the edge which is uppermoft, he releafes the fcrew of the prefs, and a fpring then caufes the fpindle to advance fo far as to relieve the flat circular plate, which is fixed upon the fpindle, from its contact with the fixed plate. This leaves the fpindle at liberty to be turned round, and the fole turns with it, fo as to bring up a new part of the edge of the leather to a convenient fituation to be pared or cut; and the fcrew is then turned to faften the fpindle as before defcribed, and at the fame time to prefs the fole between the two patterns.

When the edge of the fole is thus cut, it is carried to a grindftone, and ground fmooth: the ftone is turned with a quick motion, by means of a band and large wheel; the leather is afterwards polifhed by applying it to the edge of a wooden wheel, on which a little bees-wax is fpread.

Application of the long Nails.—The fole, thus re-inforced by the welt, is returned to the punching machine, and being attached to another pattern, a range of holes is pierced all round the outer edge, through both, juft within the former row of tacking nails; after which, by the nailing machine, thefe holes are filled with nails which project through the upper fide of the welt, being longer than any of the former, and being alfo intended to penetrate through the upper-leather and inner foles, and thus faften the fhoe together. In this ftate the fole is ready to be put to the upper-leathers.

The *upper-leathers* are prepared for applying to the fole, in the fame manner as the ordinary fhoe, *viz.* by fewing the vamp, or piece which covers the upper part of the foot, to the two quarters which go round the heel, and alfo fewing thefe two quarters together behind the heel. The workmen do not hold the work upon their knees to few it, but four men work at a fquare table, the corners of which are cut off, and a fmall piece of wood projects from each angle: the two pieces of leather which are to be fewed together are laid upon one of thefe pieces of wood in the proper pofition to be fewed, and are held faft by an endlefs ftrap, which is laid over them, and the workman binds it faft down, by preffing his foot in the ftrap, like a ftirrup. This method of fewing, which is far fuperior to the common mode, might, from its fimplicity, be ufed by all fhoe-makers, and would render their bufinefs lefs unhealthy; whereas at prefent they are fubject to many difeafes from fitting in the awkward and unnatural pofture which is neceffary to reach their work, when they hold it upon their knees.

Operation of clofing or rivetting the Shoe together.—The upper-leathers are put upon a laft, and held tight thereupon whilft the fole is applied. This is done in

The Clamping Machine.—It is a fmall oval table, fupported on a column, but capable of turning round upon the column, to enable the workman to work at any fide. In the centre of the table a laft is fixed, with the fole upwards; it is fupported at a height of about fix inches from the table. The fole is made of caft-iron, in a folid piece, with the ftem or part by which the laft is fupported; but the under part, upon which the upper-leathers are to be moulded, is made of wood, for the convenience of altering the figure when neceffary. The laft is fixed upon the table by means of two fteady pins; and a ftrong pin, which projects from the lower part of the laft, and paffes through the table, is bound faft by a wedge, which confines the laft firmly upon the table, in the fame manner as if it was made in a piece therewith. The table has a number of pieces of brafs attached to it by hinges, and arranged all round the laft in fuch a manner, that they can be turned up againft the lower part of the laft, and then form clamps, which are exactly adapted to the figure of the lower part of the laft, and will therefore clamp or bind the leather firm upon the laft at the toe, heel, and every part thereof, except at the flat part of the fole. The brafs clamps are of fuch dimenfions, that they will touch each other when turned up, and thus form a complete cell or box, in which the lower part of the laft will be contained, and the leather confined upon it; but the cell being made in feveral pieces, or clamps, they can be removed one by one, as found neceffary. The clamps are forced up to their fituation by means of an independent fcrew for each, which is tapped in an oblique direction through the edge of the table, and the point forces up the end of a fmall rod, which is jointed to the clamp near the part where it acts upon the leather: by this means the force of the fcrew acts to turn the clamp up upon its hinge, and at the fame time prefs it againft the leather. When the preffure is releafed by difplacing the end of the fmall rod from the point of the fcrew, the clamp will be fuffered to fall back upon the table; and this being

done to all the clamps, the laſt ſtands inſulated in the middle of the table, from which it can be detached by withdrawing the wedge which confines it. The inner ſole of the ſhoe is firſt put upon the ſole of the laſt, being ſlightly faſtened thereto by two ſhort pins, one of which is driven through the gauge hole in the toe of the ſole, and enters a hole made in the laſt; and the other pin is fixed in the heel part of the laſt, and enters the hole in the ſole. The upper-leathers are now put upon the laſt in the true poſition. In this ſtate, the laſt is taken to the clamping machine, and faſtened into its place in the centre of the table; the clamps are then turned up, one by one, beginning at the heel, and the upper-leathers being pulled up all round by a pair of pincers, ſo as to make them fit tight upon the laſt, the clamps are ſcrewed tight. In this ſtate, the upper-leathers are made to take the form of the laſt, being firmly attached thereto, except at the ſole part: at this part the leather ſtands up all round about three-quarters of an inch, which quantity is turned down flat upon the edge of the inner ſole (previouſly faſtened upon the ſole of the laſt), and a ſmall quantity of paſte is put in to make it ſtick faſt: four or five notches are cut out in the leather at the toe and at the heel, to make the part which is turned down lie flat upon the ſole, without folds or overlapping, and then, to make a cloſe contact, the leather is beaten down. Parings of leather are likewiſe paſted, and ſtuck flat upon the inner ſole for levelling, to make up the ſole to the ſame thickneſs in the centre as it acquires towards the edges all round by the turning-in of the upper-leathers. In this ſtate, the nail which faſtened the inner ſole to the laſt is withdrawn, being now unneceſſary, and the real ſole is applied, an iron frame, or ſaddle, being employed to determine its proper poſition upon the laſt. This frame is made of thin iron, and its figure within is ſimilar, and of the ſame ſize as the row of nails which project through the ſole, and by which the ſole is to be rivetted into its place: it is made in two halves, which are united by a joint or hinge at the heel part; and at the toe part are two holes, through which a pin can be put to hold the frame together. This pin, as well as the joint pin of the hinge at the heel, projects downwards ſufficiently to enter into a hole made in each of the two clamps at the toe and heel, in ſuch a poſition as to guide the frame, ſo that it will apply the ſole exactly in the proper poſition.

The ſole, when prepared as before deſcribed, by inſerting all the long nails in the holes, ſo that their points project through the leather, is put into an iron box or mould, and a plate being laid upon it, is put into the fly-preſs, and by a ſingle blow the ſole is rendered concave withinſide, ſo as to adapt itſelf to the laſt. When it is taken out of the mould, the iron frame before-mentioned is put together round the row of nails, the ſize of the inſide of the frame being made exactly of the proper ſize to receive the projecting points of the nails, and retain them perpendicular to the leather, and prevent them from ſpreading out. The ſole is then applied in its place by the two guide pins of the frame, and by ſtriking upon the heads of the nails, their points penetrate through the turning-in of the upper-leather, and alſo through the inner ſole. When they are well entered the iron frame is taken away, by withdrawing its pins, and opening its two halves on their joint, and the nails are driven down into their places. This cauſes them to project through the inner ſole into the ſhoe, and the points meeting the iron laſt are turned back, and thus clenched into their places. To render this more certain, the ſole of the laſt is made with a ſlight groove all round, where the points of the nails will fall, and the groove being of a ſemicircular figure, the points are more readily turned thereby, and are all turned the ſame way, ſo that they will not interfere.

The ſhoe is now put together, and the clamps being relieved and turned down, the ſhoe is taken off the laſt; for which purpoſe the heel of the laſt is made in a ſeparate piece, and jointed to the other by inclined fittings, and with a tongue or rebate, ſo that it can be held faſt in its place by a ſingle hook or ſpring catch; but this being relieved, the ſhoe draws off the laſt with the greateſt eaſe, the heel part remaining within the ſhoe, and is taken out afterwards. The ſhoe is now carried to the *rivetting laſt*, where it is put upon a laſt exactly ſimilar to that of the clamping machine, but faſtened down upon a bench, and the ſole is ſmooth without the groove, which cauſed the points of the nails to turn up. Upon this laſt the nails are beaten down, to rivet all faſt, and make the ſole ſmooth withinſide: the heel is then put on by laying it in its place, and driving down the long nails which have been put through it by the nailing machine, in the ſame manner as for the ſole.

The ſole of the ſhoe is now raſped with a coarſe file, to level all the nail-heads, and render the leather ſmooth; the ſhoes are then carried to the grindſtone, by which they are poliſhed, and finiſhed up in every part, the ſoles blacked, and poliſhed by the wheel with a compoſition of bees-wax and ivory black, which renders them gloſſy: the upper-leathers are then bruſhed by a circular bruſh, which is turned by the lathe, and the ſhoes are rendered fit for ſale, except thoſe which require binding and lining, with a lining of thin leather, in which caſe they are finiſhed in the ſame manner as common ſhoes.

Nail Machine.—This is equally deſerving of notice with any other part of this ingenious manufactory. In our article NAIL we have deſcribed ſome nail machines; but we conſider this as a much better machine for cutting brads or nails without heads. The nails are cut from ſheet-iron, the plates being firſt reduced into ſlips, of a breadth equal to the length of the intended nails, by a large pair of ſhears, acting in the ſame manner as thoſe deſcribed in the article CANTEEN, but are conſtructed in a ſuperior manner, by employing caſt-iron for the framing and for the lever. The iron plate is preſented to the machine by one man, whilſt another works the handle, and at a ſingle ſtroke cuts off the deſired ſtrip of iron: the ſheet of iron is cut ſo that the direction of the grain, or fibrous texture which the iron acquires by rolling, will be acroſs the length of the ſtrip. From this it follows, that when the nails are formed by cutting off narrow pieces from the end of the ſtrip, the grain of the iron will be the lengthwiſe of the nail.

The *cutting of the nails* is readily performed by the machine, which is turned by the foot of the workman, whilſt he ſupplies the iron by his hands. The motion of the treadle turns a crank and heavy fly-wheel, ſimilar to the wheel of a lathe: from the ſame crank a rod proceeds to the longer end of a ſtout lever, the axis of which is ſupported on pivots in the upper part of the frame, ſo as to be above the wheel and crank. At a ſmall diſtance from the centre of the lever, and at the oppoſite ſide of the axis to the long lever, a ſteel cutter is fixed, which acts againſt a fixed cutter ſupported by the frame; the fixed cutter has an edge on the upper ſide, and the moving cutter, which is fixed to the lever, is made ſharp on the lower ſide. The revolution of the wheel and crank cauſes the lever to riſe and fall, and the edges of the two cutters in this motion paſs as cloſe together as poſſible, without touching. At the moſt elevated poſition of the moving cutter, its edge riſes above the edge

of the fixed cutter so far, that the thickness of the strip of plate can be admitted between them; the end of the strip is pushed back, so that a small portion of the end of it overhangs the edge of the fixed cutter; therefore the edge of the fixed cutter, when it descends, meets this overhanging piece, and pressing it down upon the edge of the fixed cutter, cuts it off, and the piece so separated forms a nail. When the moving cutter re-ascends, the iron is pushed forwards again to overhang the fixed cutter, and another nail is thus cut off. The nails are narrow at one end to form the point, but at the other end are about as broad as the thickness of the plate, so as to be of a square figure; but at the point they are, in one direction, as broad as at the head; this is the direction of the thickness of the plate, so that in reality the nail is the figure of a small wedge instead of a pyramid, the point being in fact a sharp edge. To effect this, the cut which the machine makes across the end of the strip of iron is not perpendicular to the length of the strip, but rather inclined thereto; and at every successive nail which is cut, the inclination of the cut is reversed, so that the head of one nail is cut from the same side as the point of the next, and so on alternately of the whole length of the slip of iron. The thickness of the nail is regulated by the quantity which the end of the slip is allowed to project over the edge of the fixed cutter, and the angle of inclination by two stops, against which the edge of the slip is always brought to bear, when the workman places it ready for the cut. To stop the end of the iron, a part projects from the lever beneath the edge of the moving cutter, and is curved to the arc of a circle described from the axis: this stop is as far removed behind the edge of the cutter as the thickness of the nail intended to be cut off by the descent of the moving cutter. In working the machine, the workman keeps the wheel constantly revolving by the motion of the treadle; and holding the slip with its edge in contact with the two stops, so as to give it the proper inclination, he pushes it forwards, with a gradual pressure, against the moving cutter: then the instant the cutter is sufficiently raised to admit the slip, it will advance forwards, until the end of the slip touches the stop which is beneath the cutter: on the descent of the cutter, the nail is cut off, and the workman immediately turns the slip with the other side upwards, which has the effect of reversing the inclination of the cut; and pushing it forwards, another nail is cut as the former, and thus the operation continues with the utmost rapidity.

There are several suits of machines in this manufactory, so that a great number of shoes are proceeding at the same time through the different stages of their fabrication; and the rapidity of the execution is such, that a given number of workmen will here make a far greater number of shoes than by the common method, and they are more durable, particularly for the strong shoes which are desirable for soldiers. Several of the machines were constructed by Mr. Maudslay, with his usual accuracy of execution.

Shoe-makers' Machine.—This is a simple contrivance, to enable those artisans to perform their work in a standing posture; by which means they will avoid the diseases incident to those who follow sedentary employments.

In the common method of working, the shoe-maker is obliged to sit and stoop in the most awkward posture imaginable, sometimes in order to hold the shoe and last between his stomach and his thigh, whilst he sews the sole to the upper leather; at other times he must hold the last between his knees; and to sew the leathers together whilst he holds them upon his knees, he must lean very much forwards. In all these operations he sits as it were doubled up, so as to impede the action of his lungs, and ultimately produce many diseases. The machine is a kind of vice, to hold the shoe in any position whilst it is sewed.

The Society of Arts have shewn a laudable desire to recommend these machines to the trade; and to induce their general adoption, they have given several rewards to those who have produced machines. The first of these was Mr. Holden, then Mr. Parker, and next Mr. Stass, whose machine, being more improved than the preceding, demands some description. A small bench, or table, is firmly supported on four legs, at about four feet from the ground; a circular cushion is affixed upon the bench, having a hollow or bason in the centre of it, with a hole from the bottom of the hollow, quite through the cushion, and also through the centre of the bench. This hole receives a strap, which is doubled, and the two ends sewed together. The last is put into the double of the strap, and it is drawn down by a treadle, so as to hold the last firmly in the hollow of the cushion, which is stuffed soft withinside; and as the hole through the cushion is too small for the shoe to pass down, the last can be set in any direction which is most convenient for the sewing; but by relieving the treadle, it can be removed in an instant, turned round, and fixed again to sew another part. A seat can be applied in front of the machine, for the workman to rest himself occasionally: this seat is supported by only two legs, and a piece of wood, which projects horizontally from beneath the seat, and enters into a mortise, made in a part of the frame. Upon this the workman sits astride, as if upon a saddle; and as his work is held before him at a proper height, he sits in an upright posture, which is not attended with the same prejudicial effects as stooping to work upon the knee. The machine is provided with a small tray, or box, behind the cushion, to contain all the small articles which the work requires; also a drawer beneath it for tools, &c.; a whetstone fixed up at a convenient height; and an anvil, which fits into the hollow of the cushion, so as to lie firmly, to hammer the leather upon instead of a lapstone.

Shoe-makers are to make their shoes of sufficient leather, or forfeit 3*s.* 4*d.* (1 Jac. I. c. 22.) and journeymen shoemakers embezzling leather shall make satisfaction for damage, or be ordered by justices to be whipped, &c. Persons buying or receiving such leather, are to make reasonable recompence, to be levied by distress, &c. and search is to be made after the same: also leaving their work undertaken, or neglecting it, to be sent to the house of correction for a month. 9 Geo. I. cap. 27. 13 Geo. II. c. 8. See Leather.

Shoe, in the *Manege.* A horse-shoe is a piece of flat iron, with two branches or wings, which being commonly forged according to the form of the hoof for which it is designed, is made round at the toe, and open at the heel.

A shoe for all feet, is one that is cut at the toe into two equal parts, which is joined by a rivetted nail, upon which they are moveable in such a manner, that the shoe is enlarged or contracted less or more at pleasure, in order to make it fit all sorts and sizes of feet

To shoe a horse after the form of a lunette, a patin, &c. see Lunette, Patin, &c. See also Shoeing *of Horses,* &c.

Berenger observes, that the ancients did not shoe their horses, that is to say, they did not nail upon their hoofs any pieces of iron, or of other metal, in the form of the modern horse-shoes: but when they intended to defend them from any thing that might annoy them in travelling, they fastened upon their feet, by means of straps and ligatures, a sort of sandal, stocking, or what we call boots.

These were made of fedges twifted together like a mat, or elfe of leather, and were fometimes ftrengthened with plates of iron, and adorned by the rich and oftentatious with filver and gold, as in the inftances of Nero and Poppæa.

It does not appear in what era, or in what country, the modern art of fhoeing took its rife. The earlieft proof which the above mentioned writer has met with is the fhoe faid to have belonged to the horfe of Childeric, who lived in the year 481, and is preferved in Montfaucon's Antiquities of France. It perfectly refembles the fhoe now in ufe. Berenger's Horfemanfhip, vol. i. p. 234.

Shoes *of the Horfe and other Animals*, the crooked pieces of iron attached to the hoof of the horfe or other beafts, by means of nails. There are various forms and fhapes of fhoes in common ufe, and others which are adapted and accommodated to the particular purpofes and circumftances of the hoofs. Different forts of animals, likewife, require different forms in their fhoes. In fpeaking of the fhoe which is *concave* on its *lower furface*, it has been remarked by fome, that there are certain proportions to be obferved in its different parts. Its breadth fhould be confiderably lefs than the breadth of the common fhoe; it is totally unneceffary to cover any part of the fole, efpecially when care is taken to preferve its natural hardnefs. The breadth of the fhoe at the heels fhould be one-half of its breadth at the toe. Its thicknefs fhould decreafe gradually from the toe, fo as to be reduced one-half at the extremity of the heels. As to the diftribution of the ftamp-holes, every perfon acquainted with the fubject knows, that in fhoes for the fore-feet, they fhould be at the toe and quarters, becaufe the wall, or cruft, of the fore-feet is ftronger at the toe than at the heels. The reverfe of this is to be obferved in the hind fhoes, becaufe the heels and quarters of the hind-feet are commonly ftronger than the toe. It is impoffible to lay down any general rule for difpofing of thefe holes in bad feet; it muft be the bufinefs of the farrier to diftribute them in fuch a manner, as to be able to fix the nails in thofe parts of the cruft where the horn is found and firm. Farriers generally multiply thefe ftamp-holes too much, which brings the nails too clofe together, occafions the horn to break in fplinters, and at length deftroys the cruft.

The following number is recommended for good feet; *viz.* for race-horfes fix, that is three on each fide; for faddle-horfes feven, four on the outfide and three within, the quarter on this fide being weaker than on the other; the fame number for coach-horfes of the middling fize; for large coach-horfes four on each fide; and for cart-horfes, five on the out and four on the infide. It is alfo of principal importance to determine the *weight of the fhoe*, for it is matter of aftonifhment, to fee fome horfes with fhoes weighing each five pounds, making together a burden of twenty pounds of iron attached to their four feet. It is obvious to common fenfe, that fuch an additional weight, fixed to the extremity of the leg, muft be productive of fome inconvenience or other; and, in fact, the mufcles are thereby compelled to greater exertion; the ligaments are ftretched, and the articulations continually fatigued: and, befides all thefe evil confequences, the fhoe by its weight forces out the nails, and fo entirely fpoils the texture of the wall or cruft, that it becomes often extremely difficult to fix the fhoe to the hoof. Why then, it is afked, do not practitioners of the prefent day, who are daily witneffes of thefe facts, and indeed are the principal authors of them, apply themfelves to the correction of their own errors? The anfwer, it is feared, is obvious: becaufe he who is uneducated and deftitute of found principles in his art, cannot turn to real profit the experience he has acquired, nor abandon the path of prejudice and cuftom, in which he has fo long journied, but fatisfies himfelf with continuing to imitate and repeat whatever he has feen done by others.

The weights which are propofed, for fhoes of different kinds, are nearly as follow:

	lb.	oz.
For the ftrongeft fort of cart-horfes - -	2	12
For the fmaller horfes of this kind - - -	1	12
For the largeft coach-horfes - - - -	1	12
For the fmaller ditto - - - - -	lb. oz. 1	4
For faddle-horfes of any height - -	1	2 to 10
For race-horfes - - - - - - -	0	4 to 5

And by reducing the fuperfluous breadths of thefe fhoes, their thicknefs may, it is fuppofed, be increafed without making any addition to their weight. See Shoeing.

Shoes *of Cattle*, the fmall plates of iron that are faftened upon the feet of oxen, or other cattle employed in field or road labour. Shoes of this fort confift, according to fome, of a flat piece of iron, with five or fix ftamp-holes on the outward edge, to receive the nails: at the toe is a projection of fome inches, which paffing in the cleft of the foot, is bent over the hoof fo as to keep the fhoe in its proper place. This projection is not, however, employed in the general practice of making thefe fhoes, nor can it in common be of any utility. See Shoeing *of Oxen*.

Silk

SILK, SERICUM, a very ſoft, fine, bright, delicate thread; the work of an inſect, called *bombyx*, or the ſilk-worm.

The ancients were but little acquainted with the uſe and manufacture of ſilk; they took it for the work of a ſort of ſpider, or beetle, who ſpun it out of its entrails, and wound it with its feet about the little branches of trees. This inſect they called *ſer*, from *Seres*, a people in Scythia, whom we now call the Chineſe, who, as they thought, bred it; whence the ſilk itſelf they called *ſericum*. But this *ſer* of theirs has very little affinity with our ſilk-worm, bombyx: the former living five years; but the latter dying annually, enveloped in a yellowiſh bag or ball, which, wound out into little threads, makes what we call ſilk.

It was in the iſle of Cos that the art of manufacturing it was firſt invented; and Pamphila, daughter of Platis, is honoured as the inventreſs. The diſcovery was not long

unknown to the Romans. Silk was brought them from Serica, where the worm was a native. But ſo far were they from profiting by the diſcovery, that they could not be induced to believe ſo fine a thread ſhould be the work of a worm; and thereupon formed a thouſand chimerical conjectures of their own.

Silk was a very ſcarce commodity among them for many ages: it was even ſold weight for weight with gold; inſomuch that Vopiſcus tells us, the emperor Aurelian, who died A.D. 275, refuſed the empreſs, his wife, a ſuit of ſilk, which ſhe ſolicited of him with much earneſtneſs, merely on account of its dearneſs.

Others, however, with greater probability, aſſert that it was known at Rome ſo early as the reign of Tiberius, about A.D. 17.

Galen, who lived about the year of our Lord 173, ſpeaks of the rarity of ſilk, being no where but at Rome, and only among the rich.

Heliogabalus, the emperor, who died A.D. 220, is ſaid by ſome to be the firſt perſon who wore a holoſericum, *i. e.* a garment of all ſilk.

The Greeks of Alexander the Great's army are ſaid to have been the firſt who brought wrought ſilk from Perſia into Greece, about 323 years before Chriſt; but the manufacture of it was confined to Berytus and Tyre, in Phœnicia, whence it was diſperſed over the Weſt.

At length, two monks, coming from the Indies to Conſtantinople, in 555, under the encouragement of the emperor Juſtinian, brought with them great quantities of ſilk-worms, with inſtructions for the hatching of their eggs, rearing and feeding the worms, and drawing out the ſilk, and ſpinning and working it. Upon this, manufactures were ſet up at Athens, Thebes, and Corinth. The Venetians, ſoon after this time, commencing a commerce with the Greek empire, ſupplied all the weſtern parts of Europe with ſilks for many centuries; though ſundry kinds of modern ſilk manufactures were unknown in thoſe times, ſuch as damaſks, velvets, ſattins, &c.

About the year 1130, Roger II. king of Sicily, eſtabliſhed a ſilk manufactory at Palermo, and another in Calabria; managed by workmen, who were a part of the plunder brought from Athens, Corinth, &c. of which that prince made a conqueſt in his expedition to the Holy Land. By degrees, Mezeray adds, the reſt of Italy and Spain learned, from the Sicilians and Calabrians, the management of the ſilk-worms, and the working of ſilk; and at length the French got it by right of neighbourhood, a little before the reign of Francis I., and began to imitate them. Thuanus, indeed, in contradiction to moſt other writers, makes this manufacture of ſilk to be introduced into Sicily two hundred years later, by Robert the Wiſe, king of Sicily, and count of Provence.

It appears by 33 Hen. VI. cap. 5. that there was a company of ſilk-women in England ſo early as the year 1455; but theſe were probably employed in needle-works of ſilk and thread: and we find that various ſorts of ſmall haberdaſhery of ſilk were manufactured here in 1482; but Italy ſupplied England, and all other parts, with the broad manufacture, till the year 1489. In Spain, indeed, the culture and manufacture of ſilk ſeem to have been introduced in an early period by the Moors, particularly in Murcia, Cordova, and Granada. The ſilk manufactures of this laſt town were very flouriſhing, when it was taken by Ferdinand, &c. at the cloſe of the fifteenth century.

In 1521, the French, being ſupplied with workmen from Milan, commenced a ſilk manufacture; but it was long after this time before they could obtain raw ſilk from the worms; and even in the year 1547, ſilk was ſcarce and dear in France; and Henry II. is ſaid to have been the firſt who wore a pair of ſilk knit ſtockings; though the firſt invention originally came from Spain, whence ſilk ſtockings were brought over to Henry VIII. and Edward VI. After the civil wars in France, the plantations of mulberry-trees were greatly encouraged by Henry IV. and his ſucceſſors; and the produce of ſilk is at this day very conſiderable.

The great advantage which the new manufacture afforded, made our king James I. very earneſt for its being introduced into England: accordingly it was recommended ſeveral times from the throne, and in the moſt earneſt terms, particularly in the year 1608, to plant mulberry-trees, &c. for the propagation of ſilk-worms; but unhappily without effect; though from the various experiments we meet with in the Philoſophical Tranſactions, and other places, it appears that the ſilk-worm thrives and works as well, in all reſpects, in England, as in any other part of Europe.

However, towards the latter end of this king's reign, *i. e.* about the year 1620, the broad ſilk manufacture was introduced into this country, and proſecuted with great vigour and advantage. In 1629, the ſilk manufacture was become ſo conſiderable in London, that the ſilk-throwſters of the city, and parts adjacent, were incorporated under the name of maſter, wardens, &c. of the ſilk-throwſters; and in 1661, this company of ſilk-throwſters employed above forty thouſand perſons. The revocation of the edict of Nantes, in 1685, contributed in a great degree to promote the ſilk manufacture in this kingdom; as did alſo the invention of the ſilk throwing machine at Derby, in 1719; for an account of which, ſee SILK, *Manufacture of*.

So high in reputation was the Engliſh ſilk manufacture, that even in Italy, as Keyſler (Travels, vol. i. p. 289.) informs us, in 1730, the Engliſh ſilks bore a higher price than the Italian.

The ſilk-worm is an inſect not more remarkable for the precious matter it furniſhes for divers ſtuffs, than for the many forms it aſſumes, before and after its being enveloped in the rich cod or ball which it weaves for itſelf. From a ſmall egg, about the ſize of a pin's head, which is its firſt ſtate, it becomes a pretty big worm, or caterpillar, of a whitiſh colour, inclining to yellow. In this ſtate it feeds on mulberry-leaves, till, being come to maturity, it winds itſelf up in a ſilken bag, or caſe, about the ſize and ſhape of a pigeon's egg; and becomes metamorphoſed into an aurelia: in this ſtate it remains without any ſigns of life, or motion; till at length it awakes to become a butterfly, after making itſelf a paſſage out of its ſilken ſepulchre; and, at laſt, dying indeed, it prepares itſelf, by an egg which it caſts, for a new life; which the warmth of the ſummer weather aſſiſts it in reſuming.

As ſoon as the ſilk-worm, or caterpillar, is arrived at the ſize and ſtrength neceſſary for beginning his cod, he makes his web; for it is thus they call that ſlight tiſſue, which is the beginning and ground of this admirable work. This is his firſt day's employment. On the ſecond, he forms his folliculus, or ball, and covers himſelf almoſt over with ſilk. The third day, he is quite hid; and the following days he employs himſelf in thickening and ſtrengthening his ball; always working from one ſingle end, which he never breaks by his own fault; and which is ſo fine, and ſo long, that thoſe who have examined it attentively, think they ſpeak within compaſs, when they affirm that each ball contains ſilk enough to reach the length of ſix Engliſh miles.

In ten days' time, the ball is in its perfection; and it is now to be taken down from the branches of the mulberry-trees, where the worms have hung it. But this buſineſs

requires a great deal of attention; for there are ſome worms more lazy than others; and it is very dangerous waiting till they make themſelves a paſſage, which uſually happens about the fifteenth day.

The firſt, fineſt, and ſtrongeſt balls are kept for the breed; the reſt are carefully wound. If there be no more than can be well wound at once, they lay them for ſome time in an oven, moderately hot, or elſe expoſe them, for ſeveral days ſucceſſively, to the greateſt heats of the ſun, in order to kill the inſect; which, without this precaution, would not fail to open itſelf a way to go and uſe thoſe new wings abroad, which it has acquired within. Ordinarily, they only wind the more perfect balls. Thoſe that are double, or too weak, or too coarſe, are laid aſide; not as altogether uſeleſs, but that, being improper for winding, they are reſerved to be drawn out into ſkeins. The balls are of different colours; the moſt common are yellow, orange-colour, iſabella, or fleſh-colour. There are ſome alſo of a ſea-green, others of a ſulphur-colour, and others white; but there is no neceſſity for ſeparating the colours and ſhades, to wind them apart, as all theſe colours are to be loſt in the future ſcouring and preparing of the ſilk.

SILK, *Manufacture of.* In England, where ſilk is not produced in any quantities to be employed by the manufacturer, he muſt commence his operations upon the raw ſilk, with no other preparation than that of being wound off into ſkeins or hanks from the balls, or cocoons, which the ſilk-worms form.

In this ſtate the ſilk is imported from thoſe countries where it is produced, as Italy, Flanders, Spain, Portugal, Turkey, the Eaſt Indies, and China. A thread of this raw ſilk, drawn from the ſkein, is found to be compoſed of an aſſemblage of ſeveral of the fine fibres or threads produced by the worms; the fibres being united together by a natural gum, which is in the ſilk, and which is ſoluble in the hot water in which the cocoons are immerſed when the ſilk is wound off.

To prepare this raw ſilk for uſe, it is wound from the ſkeins upon bobbins; the compound thread is then twiſted, to unite the conſtituent fibres more firmly than they can be by the gum alone; and afterwards, being wound again upon freſh bobbins, two or three threads are twiſted together to produce a ſtronger thread, fit for the weaver, who warps and finally weaves the ſilk into various articles of ornaments or utility, by proceſſes very ſimilar to the weaving of cotton or linen, but more delicately conducted.

In the countries where the ſilk is produced, the manufacture may be more properly ſaid to commence with the operation of winding or reeling off the threads into ſkeins from the cocoons, or balls, in which the worms envelope themſelves. Theſe balls become an article of trade, as ſoon as the inſect within them is killed by expoſing them to heat, either of the ſun, or in an oven, or by the ſteam of boiling water; and, in general, the breeders of ſilk-worms ſell them, in this ſtate, to perſons who make a buſineſs of the operation of winding. In Piedmont, where capital ſilk is produced, it is conducted, as follows, by the aid of the ſilk reel repreſented in *Plate Silk Manufacture, fig.* 1.

The balls are thrown into hot water, contained in a copper baſin or boiler, A, which is about eighteen inches in length and ſix deep, ſet in brick-work, ſo as to admit a ſmall charcoal fire beneath it; or if a fire of wood is intended to be made, the fire-place muſt have a ſmall flue or chimney of iron plate to carry off the ſmoke. At the ſide of the boiler is placed the reel, which is very ſimple. B B marks the wood-framing which ſuſtains its parts: theſe are, the reel D, upon which the ſilk is wound; the layer *a*, which directs the thread upon it; and the wheel-work *b c*, which gives motion to the layer. The reel, D, is nothing more than a wooden ſpindle, turned by a handle at the end; and within the frame, at each end, it has four arms mortiſed into it, to ſupport the four battens or rails on which the ſilk is wound. The rails are parallel to the axis, and at ſuch a diſtance, that they will form a proper-ſized ſkein by the winding of the ſilk upon them, (it is uſually a yard for each revolution.) One of each of the four arms is made to fold in the middle of its length with hinges, ſo as to cauſe the rail, which theſe two arms ſupport, to fall in or approach the centre, and thus diminiſh the ſize of the reel, and admit the ſkeins of ſilk to be taken off at the end of the reel when the winding is finiſhed.

Upon the end of the wooden ſpindle of the reel, and within the frame B, is a wheel of twenty-two teeth, to give motion to another wheel, *c*, which has about twice the number of teeth, and is fixed upon the end of an inclined axis, *c b*; this, at the oppoſite end, carries a wheel, *b*, of twenty-two teeth, which gives motion to an horizontal cog-wheel of thirty-five teeth. This wheel turns upon a pivot fixed in the frame, and has a pin fixed in it, at a diſtance from the centre, to form an excentric pin or crank, and give a backward and forward motion to the ſlight wooden rail or layer *a*, which guides the threads upon the reel: for this purpoſe, the threads are paſſed through wire-loops or eyes, *a*, fixed into the layer, and the end thereof oppoſite the wheel and crank, *b*, is ſupported in a mortiſe or opening made in the frame, B, ſo that the revolution of the crank will cauſe the layer to move, and carry the threads alternately towards the right or left. There is likewiſe an iron bar, *e*, fixed over the centre of the boiler at *e*, and pierced with two holes, through which the threads paſs to guide them.

To deſcribe the operation of reeling, it ſhould be underſtood, that if the thread of each ball or cocoon was reeled ſeparately, it would be totally unfit for the purpoſes of the manufacturer; in the reeling, therefore, the ends or threads of ſeveral cocoons are joined, and reeled together out of warm water, which ſoftens their natural gum, and makes the fibres ſtick together, ſo as to form one ſtrong ſmooth thread; and as often as the thread of any ſingle cocoon breaks or comes to an end, its place is ſupplied by a new one, ſo that by continually keeping up the ſame number, the united thread may be wound to any length. The ſingle threads of the newly added cocoons are not joined by any tie, but ſimply laid on the compound thread, to which they will adhere by their gum; and their ends are ſo fine, as not to occaſion the leaſt perceptible unevenneſs in the place on which they are laid.

The woman who conducts the reeling is ſeated before the baſin A, and employs a boy or girl to turn the handle of the reel: a fire is lighted beneath the baſin A; and when the water becomes nearly boiling hot, ſhe throws into the baſin two or three handsful of cocoons, and leaves them ſome minutes, to ſoften that natural gum with which the ſilk is impregnated; then ſhe ſtirs up or bruſhes the cocoons with a wiſk of birch or of rice-ſtraw, about ſix inches long, cut ſtumpy, like a worn-out broom; the looſe threads of the cocoons ſtick to the wiſk, and are drawn out: ſhe then diſengages theſe threads from the wiſk, and by drawing the ends through her fingers, cleans them from that looſe ſilk which always ſurrounds the cocoon, till they come off entirely clean: this operation is called *la battue:* and when the threads are quite clean, ſhe paſſes four or more of them, if ſhe intends to wind fine ſilk, through each of the holes in the thin

iron bar *e*, which is placed horizontally over the centre of the basin A; afterwards she twists the two compound threads (which consist of four cocoons each) twenty or twenty-five times round each other, that the four ends in each thread may the better join together by crossing each other, and that the thread of the silk may be round, which otherwise would be flat.

The threads, after passing through the holes in the iron bar *e*, and being twisted together, are passed through the eyes of the loops, *a*, of the layer, and thence being conducted to the reel, are made fast to one of its rails. The child who turns the reel, gives it the most rapid movement possible, and thus draws off the threads from the cocoons in the basin A. The slow traversing motion of the layer prevents the threads lying over each other upon the reel, until it has made so many revolutions in the air as to dry the gum of the silk so far, that the threads will not adhere together. After the reel is covered for about the breadth of three inches, by the gradual progression of the layer, it returns and directs a second course of threads over the first laid, and so on until the required length for the skeins is obtained. The machine winds two skeins at one time. As it is essential to the production of good silk, that the thread should have lost part of its heat and gumminess before it touches the bars of the reel, the Piedmontese are by law obliged to have a distance of thirty-eight French inches between the guides, *a*, and the centre of the reel; and the layer must also, under a penalty, be moved by cog-wheels instead of an endless cord, which is sometimes used in Italy, and which, if suffered to grow slack, will cause the layer to stop and not lay the threads distinctly, and that part of the skein will be glued together, whereas the cog-wheels cannot fail.

When the skeins are quite dry the reel is removed from the frame, and by the folding of two of its arms the skeins are taken off. A tie is made with some of the refuse silk on that part of each skein where it bore upon the bars of the reel, and another tie on the opposite part of the skein; after which it is doubled into a hank, and usually tied round near each extremity, when it is laid by for use or sale.

This operation appears very simple, but to produce a good thread requires much attention. The reeler must not wait until the thread of a cocoon is entirely exhausted before she joins on another, because the threads near the end have not above a quarter of their full thickness. The cocoons produce a very unequal length; some may be met with which yield 1200 ells, whilst others will scarcely afford 200 ells. In general, the production of a cocoon may be estimated from 500 to 600 ells in length. As often as the cocoons she winds are exhausted, or break, or only diminish, she joins fresh ones to keep up the requisite number, or the proportion; because, as the cocoons wind off, and the thread becomes finer, she must join two cocoons half wound to replace a new one. Thus she can wind three new ones and two half wound, and the silk will be equal to that produced from four to five cocoons. When she would join a fresh thread she must lay one end on her finger, throw it lightly on the other threads which are winding, and the gum will join it immediately, and it will continue to go up with the rest. She must not wind off her cocoons to the last, because when they are near at an end the husk of the worm joins in with the other threads, and makes the silk foul and gouty. The silk may be wound of any size from one cocoon to 100, but it is difficult to wind more than thirty in a thread.

The nicety of the operation, and that part in which lies the greatest difficulty, is to wind an even thread, because as the cocoon winds off the end is finer, and other cocoons must be joined on to keep up the same size. This difficulty of keeping the silk always even is so great, that (excepting a thread of two cocoons, which is called such) they do not say a silk of three, four, or six cocoons; but a silk of three to four, four to five, or six to seven cocoons. In a coarser silk it cannot be calculated even so nearly as to four cocoons more or less; they say, for example, from 12 to 15, from 15 to 20, and so on.

During the operation of winding, the woman must always have a bowl of cold water by her, to dip her fingers in, and to sprinkle frequently upon the iron bar *e*, that the heat of the basin may not burn the threads, also to cool her fingers every time she dips them in the hot water, and to pour into the basin when necessary, that is, when the water begins to boil. The water must be just in a proper degree of heat; for when it is too hot, the thread is dead, and has no body; and when too cold, the ends which form the thread do not join well, and form a harsh silk. The heat of the water from which the cocoons are wound, causes that adhesion of the fibres which compose the silk: a thread can with difficulty be wound off when cold water is employed; but in this manner the adhesion is very slight, and the thread breaks with a slight force, or the least moisture will separate the fibres; but the silk wound from hot water cannot be separated except by hot water.

The old cocoons require the water to be very hot: if the threads break very frequently, it may be concluded that the water is too cold; or, on the other hand, if the silk comes off entangled, and in the state of wool, the water is too hot. When the first parcel of cocoons is finished, the basin, A, is cleaned, taking out all the striped worms, as well as the cocoons, on which there remains a little silk: these are thrown into a basket, into which the loose silk that comes off in making the battue is likewise put as waste silk, to be carded and spun into threads. The water in the basin must be changed four times a day for coarse silk, and twice only for good cocoons of fine silk: if the water is not changed, the silk will not be so bright and glossy, because the worms contained in the cocoons foul it very considerably. The reeler must endeavour to wind as much as possible with clear water, for if there are too many worms in it, the silk will be covered with a kind of dust, which afterwards attracts moths, which destroys the silk.

From the gummy or viscid material which silk gives out to water when the cocoons are infused in it, Chappe found that he was able to blow up the water into bubbles, or small balloons, far more permanent than those of soap and water, and offering all the colours of the rainbow. So close, indeed, is the texture of these silky bladders, that even the most subtile gas does not penetrate them. Chappe filled many of them, the diameter of each not exceeding three inches, with hydrogen gas, and found several of them continued in a state of suspension, in an apartment, for considerably more than twenty-four hours. It is not all silk, however, that is sufficiently glutinous for this purpose; that which is of a very deep yellow will not answer the same purpose. This silk, from its colour, is supposed to be produced by the worm in a peculiar disease, yet this is a state by no means uncommon.

All kind of silk which is simply drawn from the cocoons by the reeling, is called raw silk, but is denominated fine or coarse according to the number of fibres of which the thread is composed. In general, the raw silk requires dyeing; to prepare for which the thread is very slightly twisted, to render it strong, and more able to bear the action of the hot liquor, without separating the fibres or furring up. Silk-yarn, which is employed by the weavers for the woof or weft of the stuffs which they fabricate, is composed of

two or more threads of the raw ſilk, ſlightly twiſted in a machine; and the thread employed by the ſtocking weaver is of the ſame quality, but compoſed of a greater number of threads, according to the thickneſs deſired. Organzine ſilk is compoſed of two, three, or four threads of raw ſilk twiſted, and ſo combined as to obtain the greateſt ſtrength: for this purpoſe, each thread of raw ſilk is twiſted ſeparately upon itſelf by a mill: the twiſt is given in a right-handed direction, and extremely tight. By a ſecond operation of twiſting, two of theſe threads are combined together, the twiſt being given in a contrary direction, and not above half as tight: this forms a thread ſimilar to a rope. This deſcription of ſilk, uſed for the warp of ſtuffs, is of the utmoſt importance to the manufacturer, for none of the principal articles can be fabricated without it. The Italians, from whom we formerly imported the ſilk in the ſtate of organzine, for a long time kept the art of throwing it a profound ſecret. It was introduced into this country by the enterpriſe and ſkill of Meſſrs. Thomas and John Lombe, the latter having, at the riſk of his life, and with wonderful ingenuity, taken a plan of one of theſe complicated machines in the king of Sardinia's dominions, from which, on his return, they eſtabliſhed a ſimilar ſet of mills in the town of Derby. (See DERBY.) In conſideration of the great hazard and expence attending the undertaking, a patent was granted to ſir Thomas Lombe in 1718, for ſecuring to him the privilege of working organzine for the term of fourteen years; but the conſtruction of buildings and engines, and the inſtruction of the workmen, took up ſo much time, that the fourteen years were nearly expired before he could derive any advantage from it; in conſequence of which, he petitioned parliament, in 1731, to grant him a further term: but parliament, conſidering it an object of national importance, granted him the ſum of 14,000*l.* on condition that he ſhould allow a perfect model of the machinery to be taken, and depoſited in the Tower of London for public inſpection. Similar mills were, in courſe of time, erected in different parts of the country; but owing to the difficulties that were experienced in procuring raw Italian ſilk of the proper ſize for organzine (the exportation of which was prohibited by the Italians), and to the mills having ſubſequently found employment for other purpoſes, the quantities worked into organzine, for many years, bore ſcarcely any proportion to the imports from Italy; it has however been ſince revived and improved, in conſequence of which it is now carried on to a very conſiderable extent, as well in other parts of England as at Derby.

The proceſs which the ſilk undergoes to bring it into this ſtate, conſiſts of ſix different operations. 1. The ſilk is wound from the ſkein upon bobbins in the winding machines. 2. It is then ſorted into different qualities. 3. It is ſpun or twiſted on a mill in the ſingle thread, the twiſt being in the direction of from right to left, and very tight. 4. Two or more threads thus ſpun are doubled or drawn together through the fingers of a woman, who at the ſame time cleans them, by taking out the ſlubs which may have been left in the ſilk by the negligence of the foreign reeler. 5. It is then thrown by a mill, that is, the two threads are twiſted together, either ſlack or hard, as the manufacture may require; but the twiſt is in an oppoſite direction to the firſt twiſt, and it is wound at the ſame time in ſkeins upon a reel. 6. The ſkeins are ſorted according to their different degrees of fineneſs, and then the proceſs is complete.

The firſt operation which the raw ſilk undergoes is winding, that is, drawing it off from the ſkeins in which it is imported, and winding it upon wooden bobbins, in which ſtate it can go to the other machines. The winding-frame is ſhewn at *fig.* 2. of the plate, or rather a part of it, which will wind ſix threads at once, and by increaſing the length it may be made to receive any number. Each of the ſkeins is extended upon a ſlight reel A A, called a ſwift; it is compoſed of four ſmall rods, fixed into an axis, and ſmall bands of ſtring are ſtretched between the arms to receive the ſkein, but at the ſame time the bands admit of ſliding to a greater or leſs diſtance from the centre, ſo as to increaſe the effective diameter of the reel, according to the ſize of the ſkein, becauſe the ſkeins, which come from different countries, vary in ſize, being generally an exact yard, or other ſimilar meaſure, of the country where the ſilks are produced. The ſwifts are ſupported upon wire pivots, upon which they turn freely when the ſilk is drawn off from them; but in order to cauſe the thread to draw with a gentle force, a looped piece of ſtring, or wire, is hung upon the axis withinſide the reel, and a ſmall leaden weight, *c*, being attached to it, will cauſe a ſufficient friction. B, B, are the bobbins which draw off the threads; they are received in the frame, and are turned by means of a wheel beneath each, the bobbin having a ſmall roller upon the end of it, which bears by its weight upon the circumference of the wheel, and the bobbin is thereby put in motion to draw off the ſilk from the ſwift. D is the layer, a ſmall light rod of wood, which has a wire-eye fixed into it, oppoſite to each bobbin, ſo as to conduct the thread thereupon; and as the layer moves conſtantly backwards and forwards, the thread is regularly ſpread upon the length of the bobbin. The motion of the layer is produced by a crank fixed upon the end of a croſs-ſpindle, E, which is turned by means of a pair of bevelled wheels from the end of the horizontal axle, upon which the wheels for turning all the bobbins are fixed.

Theſe winding-machines are uſually ſituated in the top building of the mill, the frames being made of great length, and alſo double, to contain a row of bobbins and ſwifts at the back as well as in front. Two of theſe double frames are put in motion by cog-wheels from the vertical ſhaft, F, which aſcends from the lower apartments of the mill, where the twiſting-machines are placed. The winding-machines require a conſtant attendance of children to mend the ends or threads which are broken; or when they are exhauſted, they replace them by putting new ſkeins upon the ſwifts. When the bobbins are filled they are taken away, by only lifting them up out of their frame, and freſh ones are put in their places.

A patent has been lately taken out by Meſſrs. Gent and Clarke, for a new conſtruction of the ſwifts for winding-machines: they are made with ſix ſingle arms inſtead of four double ones; and the arms are ſmall flat tubes, made to contain the ſtems of wire forks, which receive the ſkein inſtead of the bands of ſtring in the common ſwifts. Theſe forks admit of drawing out from the tubes until the ſwift is ſufficiently enlarged to extend it; but as they extend the ſkein at ſix points inſtead of four, as in the common one, the motion is more regular. Inſtead of the weight which cauſes the friction, a ſpring is uſed to preſs upon the end pivot of the axis, and make the requiſite reſiſtance.

The twiſting of the ſilk is always performed by a ſpindle and bobbin, with a flyer, but the conſtruction of the machine which puts the ſpindle in motion is frequently varied. The limits of our plate do not admit a repreſentation of the great machines, or throwſting-mills, ſuch as are uſed at Derby, and at almoſt all the other great ſilk-mills in England. In *fig.* 3. we have given a drawing of a ſmall machine, which is ſimilar in the parts which act upon the ſilk; and indeed many mills employ ſuch machines conſtructed on a large ſcale.

The one in our plate contains only thirteen ſpindles, and is intended to be turned by hand, a method which is too expenſive for this country, but is common in the ſouth of France, where many artiſans purchaſe their ſilk in the raw ſtate, and employ their wives or children to prepare it by theſe machines, which they call ovals, becauſe the ſpindles *b*, *b*, are arranged in an oval frame, G H. B is the handle by which the motion is given; it is fixed on the end of a ſpindle, R, which carries a wheel, D, to give motion to a pinion upon the upper end of a vertical axle, E: this, at the lower end, has a drum or wheel F, to receive an endleſs ſtrap or band, *a a*, which encompaſſes the oval frame G, and gives motion to all the ſpindles at once. The ſpindles *b*, *b*, are placed perpendicularly in the frame G H, their points reſting in ſmall holes in pieces of glaſs, which are let into the oval plank G; and the ſpindles are alſo received in collars affixed to an oval frame H, which is ſupported from the plank, G, by blocks of wood; *d* and *a* are ſmall rollers, ſupported in the frame G H, in a ſimilar manner to the ſpindles: their uſe is to confine the ſtrap, *a*, to preſs againſt the rollers of the ſpindles with ſufficient force to keep them all in motion.

The thread is taken up as faſt as it is twiſted by a reel, K, which is turned by a wheel, *h*, and a pinion, *i*, upon the end of the principal ſpindle, R. The threads are guided by paſſing through wire-eyes, fixed in an oval frame, L, which is ſupported in the frame of the machine by a ſingle bar or rail, *l l*, and this has a regular traverſing motion backwards and forwards, by means of a crank, or excentric pin, *k*, fixed in a ſmall cog-wheel, which is turned by a pinion upon the vertical axis E; the oppoſite end of the rail, *l*, is ſupported upon a roller, to make it move eaſily. By this means the guides are in conſtant motion, and lay the threads regularly upon the reel K, when it turns round, and gathers up the ſilk upon it, as ſhewn in the figure.

One of the ſpindles is ſhewn at *r* without a bobbin, but all the others are repreſented as being mounted and in action. A bobbin, *e*, is fitted upon each ſpindle, by the hole through it being adapted to the conical form of the ſpindle, but in ſuch manner, that the bobbin is at liberty to turn freely round upon the ſpindle: a piece of hard wood is ſtuck faſt upon each ſpindle, juſt above the bobbin, and has a ſmall pin entering into a hole in the top of the ſpindle, ſo as to oblige it to revolve with the ſpindle; this piece of wood has the wire-flyer, *b*, fixed to it: the flyer is formed into eyes at the two extremities; one is turned down, ſo as to ſtand oppoſite the middle of the bobbin *e*; and the other arm, *b*, is bent upwards, ſo that the eye is exactly over the centre of the ſpindle, and at a height of ſome inches above the top of the ſpindle. The thread from the bobbin, *e*, is paſſed through both the eyes of this wire, and muſt evidently receive a twiſt when the ſpindle is turned; and at the ſame time, by drawing up the thread through the upper eye, *b*, of the flyer, it will turn the bobbin round and unwind therefrom. The rate at which the thread is drawn off from the bobbin, compared with the number of revolutions which the flyers make in the ſame time, determines the twiſt to be hard or ſoft; and this circumſtance is regulated by the proportion of the wheel, *h*, to the pinion *i*, from which it receives motion; and theſe can be changed when it is required to ſpin different kinds of ſilk. The operation of the machine is very ſimple; the bobbins filled with ſilk in the winding-machine, *fig.* 1, are put looſe upon the ſpindles at *e*, and the flyers are ſtuck faſt upon the top of the ſpindles: the threads are conducted through the eyes of the flyers *b*, and of the layers L, and are then made faſt to the reel K, upon which it will be ſeen that there are double the number of ſkeins to that of the ſpindles repreſented, becauſe one half of the number of the ſpindles is on the oppoſite ſide of the oval frame, ſo that they are hidden. With this preparation the machine is put in motion, and continues to ſpin the threads by the motion of the flyers, and to draw them off gradually from the bobbins, until the ſkeins upon the reel are made up to the requiſite lengths. This is known by a train of wheel-work at *n o p*, conſiſting of a pinion, *n*, fixed upon the principal ſpindle R, turning a wheel *o*, which has a pinion fixed to it, and turning a larger wheel *p*; this has another wheel upon its ſpindle, with a pin fixed in it, which at every revolution raiſes a hammer, and ſtrikes upon a bell, *s*, to inform the attendant that the ſkeins are made up to a proper length. When this machine is employed for the firſt operation of twiſting the organzine, the wheel, *h*, muſt be larger, and the pinion, *i*, ſmaller than repreſented, in order that the reel, K, may be turned ſlowly, and the threads will therefore receive a ſtronger and cloſer twiſt. Alſo, the handle B is turned in an oppoſite direction to that in which it muſt move for the final throwing off the two or three twiſted threads together; and as it muſt alſo move for twiſting the raw threads together for the warp of ſilk-ſtuffs, and for weaving ſtockings, this reverſe movement makes no alteration in the machine, except that it will give twiſt in a contrary direction; for it is always neceſſary, when two or more twiſted threads are combined by twiſting, that the twiſt of the original threads ſhall be in the oppoſite direction to that twiſt which unites them into one thread, in the ſame manner as for making ropes, organzine ſilk being in fact ſmall rope, and ſtocking-ſilk or warp being only yarn. The ſilk which is intended to be dyed, is previouſly twiſted very ſlightly in this machine, and of courſe in that direction which will ſuit the purpoſe for which it is ultimately intended; *viz.* whether for yarn or organzine.

The great mills for twiſting ſilk, originally introduced by Meſſrs. Lombe, though very complicated, are ſimple in their operation, becauſe the complexity ariſes from the great number of ſpindles which are actuated by the ſame movement, every one of which produces its effect independent of the others, and in the ſame manner as the oval which we have deſcribed. A machine is contained in a circular frame, of which the diameter varies from 11 to 13, 15, and even 17 feet; but 15 feet is the general ſize of the original Piedmonteſe machines. In the centre of the frame is a perpendicular axis or ſpindle, coming up through the floor of the chamber, and riſing to the cieling; it is put in motion by a communication of wheel-work from a water-wheel, or otherwiſe from a horſe-wheel. The axis has upon it two, three, or four horizontal wheels, according to the height of the machine, which revolve with it, and are of a ſufficient ſize to fill nearly all the interior of the circular frame, and act upon the pulleys or rollers of the ſpindles, which are ſupported vertically in the frame, and arranged round the machine, at equal diſtances, in a circle, the number being proportioned to the dimenſions of the machine. The ſpindles are alſo arranged in as many different ſtages of height as there are wheels upon the vertical ſpindle; for the circumference of each wheel preſſes againſt the rollers of the ſpindles which are arranged round it; and thus, when the wheel revolves, it gives a very rapid motion to all the ſpindles at once, by the contact of the edge of the wheel, but without any ſtrap, as in the oval. Each ſpindle has a bobbin, filled with ſilk, fitted upon the top of it, and from this the ſilk is carried up to a horizontal reel, which is turned round ſlowly by the machine, and draws off the thread gradually from the bobbin: the flyer, being all the while in rapid motion, twiſts the thread upon itſelf, or, if two or three threads are previouſly wound together upon the bobbin, they will be

twisted round each other. Each reel serves to take up the thread from several spindles which are situated beneath it: thus, in a mill of fifteen feet diameter, there will be six spindles beneath each reel.

To explain this machine more clearly, we will give a description of one of thirteen feet diameter, which has four large wheels and stages of spindles, two of which are for giving the first preparation to the organzine: the spindles revolve in a direction from right to left. The spindles of the other two stages are for the finishing the twist, and also for twisting the single threads which are to be used for warp or for stocking-weaving: they revolve in a contrary direction to the former. The frame of the machine consists of two wooden circles of thirteen feet diameter, one placed upon the floor of the mill, and the other at a height of fifteen feet above, the two being united by fourteen upright pillars of wood, which altogether compose a large cylindrical frame or lantern. Each stage contains eighty-four iron spindles, placed vertically, and supported in the stage, which is formed of two wooden circles, extended round between the fourteen uprights of the lantern, and fixed one above the other, at about a distance of four inches asunder, so as to support the spindles between them, in the same manner as the pieces, G, H, of the oval last described.

The circles of the stage are of a rather less diameter than the two circles which compose the top and bottom of the lantern; so that the spindles will be rather within the circle of the frame of the lantern, and admit the wheels of the central axis to act upon them. For this purpose, each of the circles of the stage is made up by fourteen segments fixed between the uprights, and each segment supports six spindles, making up the number of eighty-four in the whole circle. The spindles, like those of the oval, are sharp-pointed at the lower end, and the points rest in small holes made in pieces of glass, which are let into the lower circle of the stage, whilst the upper circle sustains the spindle at a height of four or five inches above the point, leaving full one-third of the length of the spindle projecting above, for the purpose of fitting the bobbin upon it. The upper circle of the stage is rather smaller than the lower, because the spindles do not pass through it, but through holes in small pieces of hard wood, which project from it, so as to be exactly above the pieces of glass which sustain the points of the spindles. Each spindle has a small roller fixed upon it in the space between the two circles of the stage, and it is the contact of the rim of the great wheel upon these that causes the revolution of the spindles when the wheel revolves. In order to make the contact certain, the exterior rim of the great central wheel is made in several segments, and each segment has a constant tendency to recede from the central axis by the action of a weight, and thus press against the rollers of the spindles. In order to give the reverse movement of the spindles, which we have before spoken of in the description of the oval, the great wheels for two of the stages are made differently from those which we have just described, so that the segments of the rim will act upon the outsides of the rollers of the spindles, instead of the insides: for this purpose the wheels are made larger than the stages in which the spindles are placed, and from the rim of the wheel small pillars rise up to support the segments, which act upon the rollers of the spindles in front or withoutside of the circles, instead of the inside, as is the case with the other stages, in consequence of which the spindles of these stages turn in opposite directions. The reels are placed over the bobbins, to take up the threads when twisted; and the rollers of the different spindles are made smaller or larger, as is required, to give more or less twist to the silk operated upon by them; for the velocity with which the spindles revolve, compared with the rate at which the reels take up the thread, determines the degree of twist which the thread will have; and to render this equable, the reels which draw off the silk from the bobbins of the spindles are turned regularly with the motion of the machine by means of wheel-work, which is more easily conceived than described: it is sufficient to state that it receives its motion from the central vertical axis. There is also a layer adapted to each reel, with a wire-eye to receive each thread; and the layers having a slowly reciprocating motion, distribute the threads regularly upon the reels, in a similar manner to that first described for the oval. One of these reels is placed between each of the uprights of the machine, so as to make fourteen reels in the whole circle of each stage, and every reel serves to take the silk from the bobbins of six spindles. The whole machine in the four stages contains 336 spindles.

A machine of four stages is so high, as to reach through two floors of the mill, and for this purpose the upper floor is made with a large round opening, to admit the machine: this floor serves the people who attend the machine, and change the bobbins when exhausted, and also remove the finished silk from the reels.

The spindles in the upper stages are usually devoted to the first twisting of the single threads for the organzine, and therefore turn the reverse way, as before mentioned; and as the silk is afterwards to be thrown, or re-twisted, they are drawn off from the bobbins by large bobbins of three inches diameter, and four inches long, instead of the reels. These bobbins are stuck six together upon a long spindle, situated horizontally, and turned by similar wheel-work to that which actuated the reels; they have similar layers to conduct the silk regularly upon the bobbins from one end to the other, so that the operation is not at all different.

In many of the best silk-mills, they have abandoned the original method of turning the spindles, for the preparation of organzine, the reverse way, by making the action of the wheels upon the outside, instead of the inside, of the circle of spindles. Instead of them they employ two different machines, one for the first operation on organzine, and the other for the second operation, both of them constructed with the wheels withinside: but the motion of the two machines is reversed to each other.

Fig. 5. represents a single spindle of a throwsting machine, which, though the same in its action as the great mill, is different in its construction. G and H represent portions of the rails or circles of the stage which support the spindle, and *a a* is a part of the rim of the great wheel of the central axle. This wheel is not made in segments, as before described, but is made very truly circular, and covered with leather on the edge, that it may act with more force to turn the roller, *t*, of the spindle. The point of the spindle rests in a glass cap, supported by the rail G, and the roller, *t*, is always made to press against the rim of the great wheel, *a a*, by a small lever, *d*, and a string, which, after turning over a pulley, has the weight, *e*, made fast to it, to press the spindle always towards the wheel. In this machine, instead of the reel, the thread is taken up by a bobbin, K, is put into a frame, *m*, which moves on pivots, and by a weight, *n*, is pressed down so as to make the bobbin bear upon the edge of a wheel, *b*, which is kept in constant and regular motion, by the same kind of movement which turns the reels of the great machine. The intention of this is, that the action of the wheel, *b*, to turn the bobbin, being communicated by pressure against the part upon which the silk is to wind, will be con-

ſtant, and will not draw more when the bobbin is large and full, or leſs when it is empty, as muſt be the caſe when the motion is given to the axis of the bobbin.

After the ſilk is twiſted in a right-hand direction, if it is intended for yarn, or for dyeing; or in a left-hand direction, if it is prepared for organzine; it muſt be wound on freſh bobbins, with two or three threads together, preparatory to twiſting them into one thread. In the original machines at Derby this was done by women, who, with hand-wheels, wound the threads from two or three of the large bobbins, upon which the ſilk is gathered inſtead of the reels, and aſſembled them two or three together upon another bobbin, of a proper ſize to be returned to the twiſting mill. We have ſeen an attempt for a machine to perform the doubling, which is ſlightly repreſented in *fig.* 4. The whole machine itſelf is very ſimilar to the winding-machine, *fig.* 2, but inſtead of the ſwiſt, the bobbins from the throwſting-mill are placed in front at A, *fig.* 4, two or three in a row. The threads from theſe are paſſed over the rail *m*, and beneath a piece of wood, *n*, both which, being covered with cloth, have the ſame effect to clean the ſilk by drawing through them, as the fingers of the winder. B is the bobbin upon which the two or three threads are to be wound together; it is turned by a wheel, F, upon which it reſts, the ſame as the bobbins of the winding-machine; and D is the layer, which, for convenience, is in this caſe placed behind the bobbin, B; and the wire-eye, *d*, which receives the three threads, is made to reach over to the front. The additional apparatus conſiſts of a ſmall piece of wood, *e*, which ſlides freely up and down, in a hole, through a fixed board, *f*. On the top of the ſlider, *e*, is an eye of wire, through which one of the ſingle threads of ſilk paſſes in its paſſage from between the pieces *m*, *n*, to the bobbin B: there is one of theſe ſliders, *e*, to each of the three threads; *t v* is a lever moving on the centre *w*; the end *t* is immediately beneath the ſmall ſliders *e*, and the end *v* is formed to a hook, to catch into the notches which are made in the end of the bobbin B. A ſmall counter weight, *x*, always cauſes the hook, *v*, of this lever to recede from the bobbin; but if any one of the three threads break, it ſuffers the ſlider *e*, which belongs to it, to deſcend upon the end, *t*, of the lever, and depreſſes the end of the lever, ſo as to bring the hook, *v*, in a ſituation to catch a tooth of the bobbin B, and ſtop its motion. By this means the winding of three threads together is rendered equally certain with the winding of one; for when any one breaks, the operation of winding on that bobbin ſtops, until the attendant repairs the broken thread, and puts the machine again in motion. We have lately been informed, that a machine for winding two and three threads together is becoming common in the ſilk-mills, but we do not know if it is the ſame with this one, which however is not evidently impracticable.

The bobbins, being thus filled with double or triple threads, are carried back to the throwſting machine, and are there ſpun or twiſted together, the manner of doing which does not differ from the operation which we have before deſcribed. In this ſecond operation the ſilk is taken up by reels inſtead of bobbins, and is thus made up into ſkeins. The degree of twiſt varies with the purpoſe for which the ſilk is intended; and the wheels which give motion to the reels are for this purpoſe adapted to the degree of twiſt which the ſilk is deſired to have. The ſilk, being now ſpun, requires only the preparation of boiling to diſcharge the gum, and render the ſilk fit to receive the dye, and alſo to render it ſoft and gloſſy. The ſilk is boiled for about four hours, in a boiler filled with water, into which a ſmall quantity of ſoap is put; this operation diſſolves the gum, which before could be felt upon the ſilk, and rendered it harſh. After the boiling, it is well waſhed in a current of clear water, and when dried, will be found to have loſt about one-fourth of its weight: at the ſame time the volume of the ſilk is ſenſibly increaſed, and it has acquired that ſoft texture and gloſſineſs, which are the principal beauties of ſilk. This change is produced by the diſſolution of the gum, which, in the firſt inſtance, was the only adherence of the fibre to form a thread, but by the operation of the twiſting the fibres are firmly united, and no longer require the gum. It is alſo neceſſary, in order to give a fine dye to the ſilk, that the gum ſhould be removed, becauſe it would prevent the entrance of the dyeing matter to the centre of the thread, and thus impair the beauty of the colour. If the ſilk was thus boiled before the twiſting, nothing but a fine entangled down or wool would be obtained, and it would require ſpinning, by a ſimilar proceſs to that of cotton, before a thread could be obtained. This, indeed, is neceſſary for that portion of waſte ſilk which is drawn from the cocoons in the firſt operation of reeling; alſo for thoſe cocoons which are reſerved for breeding, and from which the moths eat their way out by holes, which render it impracticable to wind off the ſilk. This waſte ſilk, when carefully ſpun by a ſpinning-wheel, is called ſpun ſilk, and the thread is not inferior to the regular ſilk which is wound off: indeed, the winding off the ſilk into a thread united by its gum, is of no advantage farther than as a preparation for ſpinning, from which proceſs the thread obtains its ſtrength.

The ſilk is now in a ſtate for uſe: if it is for ſtocking-weaving, or ſewing, or if intended for weaving into ſtuff, it only requires warping to be put into the loom. The operation of warping is to put together all the threads which are to compoſe the warp of the intended piece of ſtuff, and lay them parallel, ſo that the warp, being put into the loom, will have no ſlack threads, nor any which are ſtrained too tight. Formerly, this operation was performed by ſtretching the threads out at length in a field, or by extending them in a frame, and winding them backwards and forwards over pegs. The warping machine now univerſally employed is ſhewn in *fig.* 6, where A A is a treſſel or ſtool, which ſupports the ſmall bobbins *b*, *b*, upon which the ſilk is wound. The number of theſe is equal to the number of threads which the warp of the intended piece of ſtuff is to have in its breadth. The threads from all theſe bobbins are drawn over wires *d*, *d*, which are in front of the bobbins, and are then all brought together, and paſſed through an opening in a piece of wood D; this conducts the threads all together upon a large reel E E, which is ſupported in a frame F F F, and turned round by means of a pulley at the lower end of its axle, from which an endleſs band is continued to a ſecond wheel G, mounted on a ſpindle, and turned by a handle. This latter ſpindle is ſupported in a ſort of ſtool H, upon which a child ſits down, and at the ſame time turns the handle and puts the reel in motion, ſo as to draw the warp or aſſemblage of threads off from the ſeveral bobbins, and lay it upon the reel E. The piece of wood D is fitted upon one of the upright pieces, F, of the frame, to ſlide freely up and down upon it, and is ſuſpended by a cord, which, after paſſing over a pulley *f*, is wrapped round the ſpindle of the machine at *c*: by this means, the motion of the reel, E, draws the cord, and raiſes up the piece D, ſo as to lay the warp upon the circumference of the reel, in a regular ſpiral, from one end to the other, and prevent the coils lapping one upon another. When the required length of warp is wound upon the reel, the ends of all the threads are cut off, tied together, and thus drawn off from the reel and rolled up into a large ball,

in which ftate the weaver takes it, and mounts it in his loom.

For the fubfequent operations of weaving we fhall refer to the article WEAVING, becaufe the weaving of filk goods is the fame as for any other, except that finer and more beautiful articles are produced in this fubftance than in any other. Some information on the details of weaving mechanifm will be found under our articles DRAUGHT *of Looms*, DRAW-*Loom*, DIAPER, DIMITY, and DORNOCK; and though thefe are rather the weaving of linen and cotton than filk, the fame principles apply to filk, as will be more fully explained under WEAVING; where a defcription of weaving ribbands and figured filks will be given.

Silk is diftinguifhed by different names according to its different ftates. Thus,

SILK, *Spun*, is that taken from the ball, without fire, and fpun into thread without any coction: fuch as is moft, if not all, that is brought into England from the Levant; *i. e.* from Perfia by the way of Turkey, from Bengal in India, and from China. The raw fpun filk is commonly worked up into two forts, called *organize* and *tram*: the former is made by giving a throw or twift to each thread of raw fpun filk fingly, and then doubling two of thefe twifted threads together, and twifting them fmartly together; this forms the warp or length of a piece when manufactured. The tram, or fhoot, which makes the breadth of the piece, is formed by twifting two or more threads of raw filk flack. The wafte raw filk, or refufe in reeling, &c. is collected, carded, and fpun, and called *flofs* filk; this is doubled and thrown, and often made into a cheap fort of filk-ftockings, which are very ftrong and durable.

In the French filk-works, the greateft part of this raw filk paffes for little better than a kind of fine floretta; yet, when fpun, it makes a bright thread, and ferves for the manufacture of ftuffs of moderate value and luftre. But the fpun filks of the Levant, whence moft of our's come, are exceedingly fine and beautiful. The difference arifes hence, that in France, the beft balls are reeled off in boiling water, and only the refufe made into fpun filk; whereas, in the Levant, there is no fuch thing as reeling or winding on the fire, but the filks are all fent in bales, or packs, as they are drawn from off the balls; fo that they are only diftinguifhed by their quality of fine, middling, and coarfe.

SILK, *Boiled*, is that which has been boiled in water, to facilitate the fpinning and winding. This is the fineft of all the forts of filk manufactured in France, and is feldom ufed but in the richeft ftuffs; as velvets, taffeties, damafks, brocades, &c.

There is alfo another kind of boiled filk, which is prepared by boiling, to be milled; and which cannot receive that preparation, without being firft paffed through hot water. By the laws of France, it has been prohibited to mix raw with boiled filk; both as fuch a practice fpoils the dyeing, and as the raw filk corrupts and cuts the boiled.

SILKS, *throwed* or *twifted*, are fuch as, befides their fpinning and winding, have received their milling or throwing.

This they receive in a different degree, as they are paffed oftener or feldomer over the mill; properly, however, throwed filks are thofe in which the threads are pretty thick-throwed, and twifted feveral times.

The thrown filk comes to us chiefly from Leghorn, Genoa, Naples, and Meffina.

SILKS, *Slack*, are fuch as are not twifted, but are prepared, and dyed for tapeftry, and other works with the needle.

SILK. *Eaftern* or *Eaft Indian*. That popularly thus called is not the work of the filk-worm, but comes from a plant that produces it, in pods, much like thofe of the cotton-tree. The matter this pod contains is extremely white, fine, and moderately gloffy; it fpins eafily, and is made into a kind of filk, that enters the manufacture of feveral Indian and Chinefe ftuffs.

SILKS, *French*. It is only in the moft fouthern provinces of France that filk is cultivated, mulberry-trees planted, and worms bred. The principal places are Languedoc, Dauphiné, Provence, Avignon, Savoy, and Lyons This laft place, indeed, furnifhes very few filks of its own growth; but it is the great ftaple whence the merchants of Paris, and the other cities, are to fetch them. At leaft, they are obliged to have them pafs through Lyons, if they bring them from other places, either by land or fea. There have been computed to enter Lyons, *communibus annis*, fix thoufand bales; the bale valued at one hundred and fixty pounds weight; of which fix thoufand bales, there are one thoufand four hundred from the Levant, one thoufand fix hundred from Sicily, one thoufand five hundred from Italy, three hundred from Spain, and one thoufand two hundred from Languedoc, Provence, and Dauphiné.

At the time when the manufactures of Lyons were in their profperity, there were reckoned to be eighteen thoufand looms employed in the filk manufacture; but in 1698, there were not reckoned four thoufand. However, this manufacture afterwards revived, and a great part of Europe has been fupplied from hence with brocade and rich filks. The decay has not been lefs notable at Tours; they had formerly there eight hundred mills for winding and preparing the filks; eight thoufand looms to weave them; and forty thoufand perfons employed in the preparation and manufacturing of them; but thefe have been reduced to feventy mills, twelve hundred looms, and about four thoufand perfons. The revolution has, however, made fuch an alteration in the manufactures and trade of France, and they are ftill (1816) in fo unfettled a ftate, that no correct eftimate of them can be obtained.

SILKS, *Sicilian*. The commerce of the filks of Sicily has been very confiderable; and the Florentines, Genoefe, and Luccefe, are the people who have chiefly availed themfelves of it. Great quantities were yearly brought thence, efpecially from Meffina; part of which they ufed in their own manufactures, and fold the reft to their neighbours the French, &c. with profit. The Italians had this advantage, efpecially the Genoefe, over other people, that, having large eftablifhments in the ifland, they were reputed as natives, and paid no duty for the export.

Part of the Sicilian filks is raw, the reft are fpun and milled; of which laft kind, thofe of St. Lucia and Meffina are the moft valued. The raw unwrought filks were always fold for ready money; the others, fometimes, in exchange for other goods. See SICILY.

SILKS, *Italian*. The filks brought from Italy are partly wrought, and partly raw and unwrought. Milan, Parma, Lucca, and Modena, furnifh none but the latter kind; Genoa moft of the former; Bologna affords both kinds. The fineft Italian wrought filk comes from Piedmont, Novi, Bergamo, and Bologna; and is imported into England from the ports of Nice, Genoa, and Leghorn.

The filk we have from Italy is generally thrown, and ferves for warp for our manufactures.

SILKS, *Spanifh*, are all raw; and are fpun, milled, &c. in England, according to the feveral works in which they are to be ufed.

SILKS, *Turkey*, are all raw. One advantage we have in the commerce of the Levant, in filks, wanting in thofe of Sicily, is, that the latter are confined to a particular feafon of the year; whereas the former are bought at all times.

They are brought from Aleppo, Tripoli, Sayda, and from the isle of Cyprus, Candia, &c. But the principal place of commerce, especially for the silks of Persia, is Smyrna. The silks are brought hither in caravans, from the month of January to September. The caravans in January are loaden with the finest silks; those of February and March being indifferent ones; the rest, the coarsest. They all come from the several provinces of Persia, chiefly those of Ghilan and Shirvan, and the city of Schamachia, situate near the edge of the Caspian sea; from which three places, a Dutch author assures us, there have not come less than thirty thousand bales of silk in a year. Ghilan produces the best and greatest quantities of silk; next to this are Shirvan and Erivan, then Mazanderan, and lastly Astrabad; but the latter is much inferior, serving only for a manufacture mixed with cotton; that of Mazanderan and Astrabad is seldom or ever exported.

Ardeuil, or Ardebil, another city of Persia, not far distant from these silk countries, is the place where silks are laid up, and whence the caravans set out for Smyrna, Aleppo, Scanderoon, and Constantinople; and it is this city, with Schamachia, that have always been esteemed the centre of the silk trade; which has been several times attempted to be removed from Smyrna, and the Mediterranean, in favour of Archangel, and the White sea, by carrying them across Muscovy, by the Volga and Dwina, two rivers that traverse the principal provinces of that vast empire.

This new course of the Persian silks into Europe was first proposed by Paolo Centurio, a Genoese, to the tzar Bazil, under the pontificate of Leo X. The French had the same design in 1628. The duke of Holstein, in 1633, sent ambassadors to the court of Persia, purely with the same view. And in 1668, the tzar Alexis Michael attempted the thing himself; but he was disappointed by the rebellion of the Cossacks, and the surprise of Astrakhan.

In 1688, the commerce of Persian silks had nearly been removed from Smyrna by an earthquake, which almost overturned the whole city; and, doubtless, the removal had been effected, but for the vigorous means used by the Turks to prevent it. Smyrna, however, still remains in her ancient possession; and the several nations of Europe continue every year to send their fleets, to fetch away the silks.

SILKS, *China*, *Japan*, and *Indian*. Several provinces of China are so fertile in mulberry-trees, and their climate is so agreeable to the nature of silk-worms, that the quantity of silks there produced is incredible; the single province of Tchehiang might supply all China, and even a great part of Europe, with this commodity. The silks of this province are the most esteemed, though those of Nankin and China be excellent.

The silk-trade is the principal in China, and that which employs the most hands; but the European merchants who deal in it, especially in wrought silks, are to be careful of the spinning, &c. the waste being usually very great, as the French East India company have found to their cost.

Japan would not afford fewer silks than China; but that the Japanese, a barbarous and distrustful people, have interdicted all commerce with strangers, especially with Europeans, excepting with the Dutch; who are said to be admitted on certain impious terms, related by Tavernier, but which, we must own, we cannot credit. The Dutch have endeavoured to vindicate themselves from these by the pens of several famous writers.

Great quantities of both raw and wrought silk are furnished by other parts of Bengal, and by several provinces of Hindoostan, which partly supply the natives, and afford a very considerable exportation to Europe. Several thousand bales of raw silk are annually imported from Bengal and China; some of which is, in this state, used for making princes' stuffs, but the greater part is prepared for the manufacturers by the silk-throwsters.

SILK, *Laws relating to.* The duties on silks and callicoes being under the same regulations with those on printed linens, the law respecting them is inserted under the article LINEN. By the 13 & 14 Car. II. c. 15. s. 2. no person shall exercise the trade of a silk-throwster, unless he hath served seven years' apprenticeship, on pain of 40*s.* a month, half to the king, and half to him that shall sue in any court of record, or at the assizes, or quarter-sessions of the peace. By 9 & 10 W. c. 43. no foreign silks, called alamodes or lutestrings, shall be imported but in the port of London, on notice first given to the commissioners of the customs, and licence had from them, on pain of forfeiture, or the value; and they shall be sold, and exported again; and the offender so importing, and also the receiver and person offering to sell the same, shall forfeit 500*l.* Being marked and sealed by order of the commissioners, any person who shall counterfeit the custom-house seal, or that of the lutestring company, shall forfeit 500*l.*, and be set in the pillory for two hours. And any person who shall buy and sell, and have in his custody, any alamodes or lutestrings, sealed or marked with a counterfeit seal or mark, shall forfeit the same and 100*l.*

However, none but custom-house officers, or persons deputed by the lutestring company, and having writs of assistance under the seal of the exchequer, shall seize lutestrings or alamodes within the bills of mortality. (5 Ann. c. 20.) The penalties shall be two-thirds to the king, and one-third to him that shall seize or sue in any court of record.

By 3 Geo. III. c. 21. and 5 Geo. III. c. 48. if any person shall import any ribbands, laces, or girdles, not made in Great Britain, whether the same shall be wrought of silk alone, or mixed with other materials, the same shall be forfeited, and may be seized by any officer of the customs, in whatever importers', venders', or retailers' hands they may be found; and the importer, and every person assisting therein, and the venders and retailers in whose custody they shall be found, or who shall sell or expose the same to sale, or conceal with intent to prevent the forfeiture, shall forfeit respectively 200*l.*, with costs. Half the said penalties to be to the king, and half to the officer who shall inform and prosecute.

But if any officer of the customs shall neglect or refuse, for one month after condemnation, to prosecute to effect any person for any of the said pecuniary forfeitures, any other person may sue for and recover the same; half thereof to go to the king in like manner, and half to him who shall sue.

And when the goods seized (being out of the limits of the bills of mortality) shall not exceed the value of 20*l.*, two justices, on information before them that such goods were seized, as unduly imported, may hear and determine the same, and proceed to condemnation or discharge.

After seizure, until condemnation or discharge, the said goods shall be deposited in one of the king's warehouses, if the seizure be within the bills of mortality; elsewhere, in the hands of the chief magistrate or constable; and the same shall be free to inspection, with leave of the court, judge, or justices, before whom the prosecution shall be.

And after condemnation, the said goods shall be publicly sold by the candle for exportation; half of the produce by

fuch fale to be to the king, and half to the officer who fhall feize and fecure the fame; and the fame goods fhall not be delivered out of the warehoufe, till fecurity fhall be given for exportation, and that the fame fhall not be landed again in any part of his majefty's dominions.

By 5 Geo. III. c. 48, if any foreign manufactured filk-ftockings, filk-mitts, or filk-gloves, fhall be imported into this kingdom, or any part of the Britifh dominions, the fame fhall be forfeited, and liable to be fearched for and feized as other uncuftomed goods; and every perfon who fhall import the fame, or be affifting therein, and the venders and retailers in whofe cuftody they fhall be found, or who fhall fell or expofe the fame to fale, or conceal with intent to prevent the forfeiture, fhall, over and above the forfeiture of the goods, forfeit 200*l.*, with cofts; half to the king, and half to the officer who fhall inform and profecute.

And when the goods feized (being out of the limits of the bills of mortality) fhall not exceed the value of 20*l.*, two juftices may proceed to the condemnation thereof. And the proceedings, in all other refpects, fhall be in like manner as in the cafe of ribbands and laces above mentioned.

Silk, in *Chemiftry*, deferves notice on account of a peculiar falt, or cryftalline fubftance, obtained from it by the nitric acid. In its natural ftate, or before it is bleached, it contains a yellow refinous matter, from which it derives its fine golden colour. When raw filk is infufed in water, a portion of gummy matter is diffolved, and a light amber-coloured liquor is produced. Pure alcohol extracts a much deeper yellow colour, and makes a tincture, that lofes none of its colour by long expofure to the fun, which bleaches the filk itfelf. Nitrous acid acts powerfully on filk, in proportion to its concentration. If two drachms of this acid are mixed with a pint of alcohol, and filk, either raw or bleached, be immerfed in it, and kept in digeftion, in a moderate warmth, for twenty-four hours, the filk becomes of a dull yellowifh-brown, which, after rinfing and wafhing with foap, and drying, turns to a fine golden yellow, which is very permanent. But when concentrated nitric acid is diftilled off filk, and the remaining liquor duly evaporated, much oxalic acid is obtained; and the refidue, if evaporated ftill further, yields, together with a little remaining oxalic acid, a quantity of yellow granular cryftals, very bitter, not acid, and ftaining the faliva and hands of a very deep yellow, not eafily removed. If the liquor is previoufly faturated with potafh, and evaporated, another yellow filky falt evaporates, which detonates on coals like common nitre, and appears to be a triple combination of the former bitter fubftance with nitrate of potafh. The firft mentioned granular cryftals, examined with a magnifier, appear to be compofed of truncated octohedrons.

The above curious fubftance was difcovered by Welter, and called by him the "bitter principle." He fuppofes it to be generally produced by the action of nitric acid on animal matters; and it is perhaps the fame fubftance which caufes the bitternefs of bile. Aikin.

The fpirit of raw filk, rectified with fome effential oil, is the medicine commonly known by the name of *Guttæ Anglicanæ*, or Englifh drops.

Silk, *Spider*. Within about a century the fecret has been found in France, of procuring and preparing filk from the webs of fpiders; and the ufing it in feveral manufactures has been attempted. This difcovery is owing to M. Bon, in 1710, who publifhed a differtation on the fubject, whence what follows is extracted.

Spiders are ufually diftinguifhed, either with regard to their colour, as into black, brown, yellow, white, &c. or with regard to the number, or arrangement, of their eyes; fome having fix, others eight, others ten. But with regard to the filk-fpiders, M. Bon reduces them all to two kinds; thofe with long legs, and thofe with fhort: which laft are thofe which furnifh the fineft raw filk. The filk-fpider makes a filk every whit as beautiful, gloffy, and ftrong, as the filk-worm: it fpins it from the anus; around which are five papillæ, or fmall nipples; and behind thefe, two others, all mufculous, and furnifhed with fphincters. Thefe nipples ferve as fo many wire-drawing irons, to form and mould a vifcous liquor, which, when dried in the air, after being drawn through them, makes the filk. Each of thefe nipples, M. Reaumur obferves, confifts of a number of lefs and infenfible ones; which one may be convinced of by preffing a fpider's belly between the fingers, to oblige the liquor to flow into the nipples; for by this means, applying the finger againft the anus, feveral diftinct threads will be drawn out through the feveral perforations of each nipple. The threads are too fine to be counted with any certainty; but M. Reaumur reckons each larger nipple may fend forth a great many.

Hence we fee how the fpiders make their threads bigger or fmaller: for as, before they begin to fpin, they always apply more or fewer of thefe nipples againft the body whence the web is begun; or, as they apply each more or lefs ftrongly; fo, as more or fewer of the minuter nipples come to take, the thread thus fpun will be a compound of more or fewer of the fingle threads. Indeed, as the threads come from the anus all joined together, they appear to be fingle; but M. Bon has diftinguifhed one of the fingle ones to confift of fifteen or twenty diftinct threads.

The threads are of two kinds: the firft is weak, and only ferves for that kind of web with which they catch flies. The fecond is much ftronger, and ferves to wrap up their eggs in; which, by this means, are fheltered from the cold, as well as from infects, which might otherwife gnaw and deftroy them. Thefe threads they wind very loofely round the eggs, refembling the balls or bags of filk-worms, that have been prepared and loofened for the diftaff.

The fpider-bags are of a grey colour, when new; but they turn blackifh, when long expofed to the air: indeed, one might find other fpiders' bags of other colours, and which would afford a better filk; but their fcarcity would render the experiment difficult: for which reafon, we confine ourfelves to the bags of the moft common fpiders, which are the fhort-legged kind. Thefe always find out fome place, fecure from the wind and rain, to make their bags; as hollow trees, the corners of windows, or vaults, or under the eaves of houfes.

By collecting a quantity of thefe bags, a new filk is made, inferior in nothing to the common filk. It takes all kinds of dyes, and may be made into all kinds of ftuffs. M. Bon had ftockings and gloves made of it, which he prefented to the Academy, and others to our Royal Society.

For the manner of preparing the bags to get the filk, it is thus: after having gathered twelve or thirteen ounces of thefe bags, M. Bon had them well beaten for fome time, with the hand, and a ftick, to get out all the duft; he then wafhed them in lukewarm water, till they left the water very clean: after this, he laid them to fteep, in a large veffel, with foap, and faltpetre, and gum arabic. The whole was left to boil, over a gentle fire, for three hours. The bags were next wafhed in warm water, to get out the foap; and after all, laid to dry fome days, to fit them

for carding; which was performed by the common silk-carders, but with cards much finer than ordinary. By this means, he had a silk, of a very particular ash-colour, which was easily spun; and the thread spun from it was both stronger and finer than that of common silk; which shews, that all sorts of works may be made of it: nor is there any reason to fear, but it will stand any trials of the loom, after having passed that of the stocking-weavers.

The only difficulty, now, is in procuring a sufficient quantity of spider-bags to make any considerable work of it; which, M. Bon observes, would be no difficulty at all, had we but the art of breeding them, as we do silk-worms; for they multiply much more; every spider laying six or seven hundred eggs, whereas the silk-worms do not lay above one hundred: yet are these last so tender, &c. that one half die without making any bags, or are hindered, by some little accident, from making them; whereas the spiders hatch of themselves, without any care, in the months of August and September, in fifteen or sixteen days after they are laid; the old spiders that lay them dying soon after. The young ones thus bred live ten or twelve months without eating, and continue in their bags without growing, till the hot weather, putting their viscid juices in motion, induces them to come forth, spin, and run about to seek food. Were a method, therefore, found of breeding young spiders in rooms, they would, doubtless, furnish a much greater quantity of bags than silk worms do. For of seven or eight hundred young spiders, which M. Bon kept, hardly one died in a year; whereas of one hundred silk-worms, not forty lived to make their bags. M. Bon, having ordered all the short-legged spiders that could be found in the months of August and September to be brought to him, shut them up in paper coffins, and pots; covering the pots with papers, which he pricked full of pin-holes, as well as the coffins, to give them air. He fed them with flies, and found, some time afterwards, that the greatest part of them had made their bags. The same ingenious person found, that spiders' bags, with regard to their weight, afford much more silk than those of the silk-worms: as a proof of which, he observes, that thirteen ounces yield near four ounces of clear silk, two ounces of which will make a pair of stockings; whereas stockings of common silk weigh seven or eight ounces.

Nor is there any venom in the silk, or even in the spider, as many have imagined. M. Bon has been bit by them several times, without any manner of harm; and as for the silk, it is used with very good success to stop bleeding, and cure wounds, the natural gluten of it acting as a kind of balsam. It likewise yields, by distillation, several specific medicines, particularly great quantities of spirit, and volatile salt, which being prepared after the same manner as that drawn from the bags of silk-worms, in making the guttæ Anglicanæ, or English drops, at one time so famous all over Europe, may serve to make other drops of greater efficacy, which M. Bon calls drops of Montpelier, and advises to be used in all sleepy diseases.

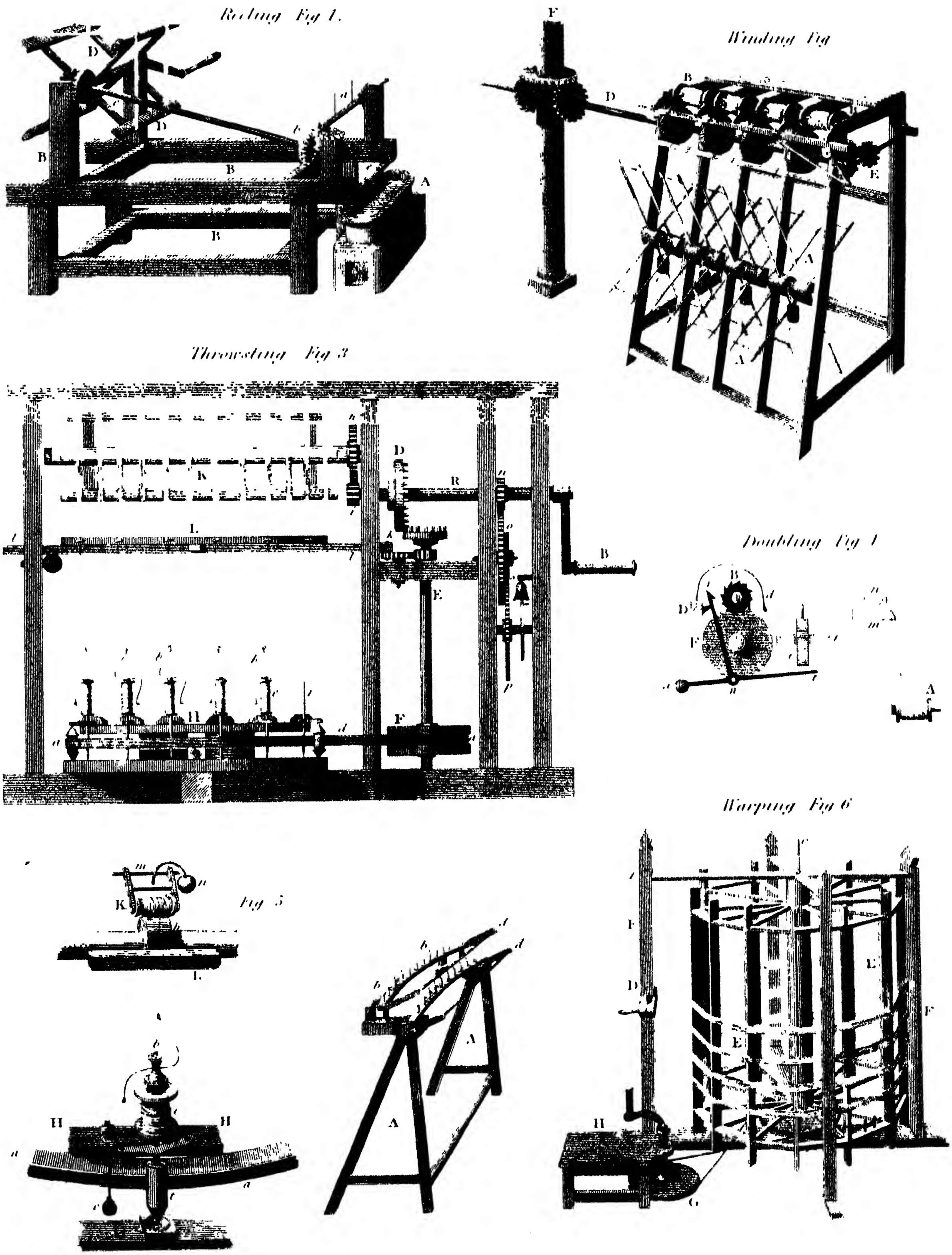
M. Reaumur, being appointed by the Royal Academy to make a farther inquiry into this new silk work, has raised several objections and difficulties against it; which are found in the Memoirs of the Academy for the year 1710. The sum of what he has urged amounts to this. The natural fierceness of the spiders renders them unfit to be bred and be kept together: four or five thousand being distributed into cells, fifty in some, one or two hundred in others, the big ones soon killed and eat the less, so that, in a short time, there were scarcely left one or two in each cell; and to this inclination of mutually eating one another, M. Reaumur ascribes the scarcity of spiders, considering the vast number of eggs they lay.

But this is not all: he even affirms, that the spider's bag is inferior to that of the silk-worm, both in lustre and strength; and that it produces less matter to be manufactured. The thread of the spider's web, he says, only bears a weight of two grains without breaking; and that of the bag bears thirty-six. The latter, therefore, in all probability, is eighteen times thicker then the former; yet it is weaker than that of the silk-worm, which bears a weight of two drachms and a half: so that five threads of the spider's bag must be put together, to equal one thread of the silk-worm's bag.

Now it is impossible these should be applied so justly over one another, as not to leave little vacant spaces between them, whence the light will not be reflected; and of consequence, a thread, thus compounded, must fall short of the lustre of a solid thread. Add to this, that the spider's thread cannot be wound off, as that of the silk-worm may, but must of necessity be carded; by which means, being torn in pieces, its evenness, which contributes much to its lustre, is destroyed. In effect, this want of lustre was taken notice of by M. de la Hire, when the stockings were presented to the Academy.

Again: spiders furnish much less silk than the worms: the largest bags of these latter weigh four grains; the smaller, three grains; so that 2304 worms produce a pound of silk. The spider-bags do not weigh above one grain; yet when cleared of their dust and filth, they lose two-thirds of their weight. The work of twelve spiders, therefore, only equals that of one silk-worm; and a pound of silk will require at least 27,648 spiders. But as the bags are wholly the work of the females, who spin them to deposit their eggs in, there must be kept 55,296 spiders to yield a pound of silk. Yet will this only hold of the best spiders; those large ones ordinarily seen in gardens, &c. scarcely yielding a twelfth part of the silk of the others: 280 of these, he shews, would not yield more than one silk-worm; 663,552 of them would scarcely yield a pound.

SILK MANUFACTURE



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Silver

Silver, in the *Arts*, *Manufactures* and *Commerce*, and in *Domestic Economy*, is a white malleable metal, susceptible of a fine polish. In *Chemistry*, it is a simple inflammable body.

It is sometimes found in the native state, but more frequently combined with antimony, arsenic, or sulphur; forming the varieties of silver-ores; with which we shall begin, and then proceed to the assay and analysis, physical properties, and chemical properties of silver.

Silver-ores contain that metal either native, or alloyed with other metals, or mineralized by sulphur, and sometimes with the muriatic acid, the sulphuric acid, and in one rare instance with the carbonic acid.

Silver-ores principally occur in the rocks which have been denominated primary and transition rocks, and rarely in secondary rocks; but many rich argentiferous lead-ores occur in alpine lime-stone and secondary strata. The ores of silver are accompanied by calcareous spar and sulphate of barytes, and sometimes with quartz, horn-stone, jasper, and fluor spar. It has been remarked, that the warmer regions of the globe afford the greatest quantity of gold, but the richest repositories of silver are situated either in high latitudes or in elevated regions. The most celebrated silver-mines of Europe are in Sweden and Norway, at no great distance from the polar regions; and those which are in warmer latitudes, are almost all situated near the summits of alpine mountains commonly covered with snow, as at Allemont in France, and the mines of Mexico and Peru, in the centre of the Cordilleras. Silver never occurs, like gold, in alluvial soil, or the sands of rivers. After the mineralogical description of the ores, we shall give a short account of the principal repositories of silver at present known.

Native silver, *Argent natif* of Haüy, possesses the characters of silver extracted from other silver-ores, but is generally less malleable. The colour is pure white, but the surface is commonly tarnished, and is of a yellowish-brown or greyish-black. Native silver occurs crystallized in cubes and octohedrons; the crystals are small, and are often aggregated, forming beautiful ramifications; the branches sometimes cross each other in a rectangular direction, and are reticulated. It is sometimes in leaves and sometimes capillary, and when the filaments are much entangled, it becomes nearly compact. Native silver is also found in shapeless masses of considerable size. In the year 1750, there was found in the famous mine of Hemmels Furst, near Freyberg, in Saxony, a mass of native silver, which weighed one hundred weight and a quarter; in 1771 an equally large mass was found. It is also mentioned by Albini, in his "Meissnische Berg Arconicke," p. 30, "that at Schneeberg, in 1478, a rich silver vein was discovered, and so large a block of native silver cut out, that duke Albert of Saxony descended into the mine, and used this large block as a table to dine upon. It was smelted into four hundred centners of silver: a centner is 110 lbs." (Jameson's Mineralogy.) Native silver is fusible into a globule, which is not altered by a continuance of the heat: it is scarcely ever pure: the metals with which it is alloyed are commonly gold, copper or arsenic, and iron. Native silver alloyed with gold is rare; its colour is intermediate between silver-white and brass-yellow; it often contains a considerable proportion of gold. The stones which form the matrix of native silver in the mine are very numerous; it sometimes appears to be infiltrated into the fissures, sometimes to vegetate on the surface, and in other instances to be intimately combined with the substance of the stone. It is found in almost all the silver-mines that are worked in Europe or America; but the masses discovered in America are not so large as some which have been found in Europe. The *pacos*, a most abundant ore in Peru and Mexico, consists of minute particles of native silver, intermixed with brown oxyd of iron; but the particles are too small to be seen without a lens, and bear but a very small proportion to the mass. Silver rarely occurs in detached grains, like gold or platina.

Antimonial silver-ore is composed of silver combined with antimony, without any other substance. Its colour is tin-white; it has a shining metallic lustre, which is often tarnished superficially reddish or yellowish. It is distinguished from native silver by its brittleness, being scarcely malleable: the structure is lamellar. It is commonly found crystallized in four-sided and six-sided prisms, having the sides deeply striated: its specific gravity is from 9.4 to 9.8. It melts easily before the blowpipe, giving a white smoke from the oxyd of antimony, and leaving a globule of silver. Its constituent parts are from .76 to .84 silver, and from 16 to 24 of antimony. Antimonial silver is rare, particularly the regular crystallizations of it. It occurs in veins with calcareous spar and sulphate of barytes, and is accompanied by galena and native silver. The foliated structure of antimonial silver distinguishes it from white cobalt-ore, which has a granular structure; it differs also from arsenical pyrites, both by its structure and softness; the latter is extremely hard. Antimonial silver yields to the knife.

Arsenical silver-ore is harder than the former species; its

ftructure is lefs perfectly lamellar, the fracture more even, and the luftre weaker. It occurs in fmall, globular, and kidney-fhaped maffes; before the blowpipe it yields the fmell of garlic, peculiar to arfenic; a globule of filver more or lefs pure remains. The conftituent parts of this ore are given by Klaproth as under;

Silver	- -	16
Arfenic	- -	35
Iron	- -	44
Antimony	- -	4

Arfenical filver-ore ufually occurs with native arfenic; dark red filver-ore, brittle filver-glance, lead-glance, and brown blende, in calcareous fpar. It is a fcarce mineral.

Corneous filver-ore, or *Horn-ore; Argent muriaté*, Fr. This mineral is diftinguifhed by its tranflucency; it has a waxy or gliftening luftre, is foft and tenacious, and yields to he nail. From thefe characters it is fuppofed to bear fome refemblance to horn, whence its name. The moft common colours of this mineral are pearl-grey, paffing into greenifh or reddifh-blue or brown; it acquires a brownifh tarnifh. Horn-filver occurs cryftallized in fmall cubes, and is fometimes, though rarely, acicular and capillary: it is more commonly in laminæ or fmall maffes, or forms a coating on native filver. It is fufible in the flame of a candle. Under the blowpipe, on charcoal, it yields a globule of filver, and gives out a difagreeable odour, from the efcape of the muriatic acid. Its fpecific gravity is from 4.75 to 4.80. Horn filver-ore is accompanied with native filver, black filver-ore, brown oyxd of iron, quartz, and fulphate of barytes. It is fuppofed by fome mineralogifts to be the moft recent formation of filver-ore. It occurs in veins in the filver-mines of Europe and America, and in Siberia, and is obferved generally to occupy the upper part of the vein. According to Klaproth, it confifts of 68 parts filver, 21 muriatic acid, a fmall quantity of fulphuric acid, with a portion of iron and earthy fubftances; but the latter may be confidered as accidental. Horn-filver is rather a fcarce mineral.

Vitreous filver-ore; Silver-glance, or *fulphuretted filver; Glaferz*, Werner; *Argent fulfuré*, Haüy. Its colour is a dark lead-grey; it is malleable, and may be cut with a knife; the furface, when cut, is fhining, and has a metallic luftre; in its natural ftate it has often an iridefcent tarnifh. It occurs in a variety of forms, in branches, fibres, fmall irregular maffes, and laminæ, and is alfo frequently cryftallized: the cryftals are commonly the cube or octohedron, and the dodecahedron, with rhomboidal faces: the fracture is flatly conchoidal. The fpecific gravity of this ore is from 7.0 to 7.2: its conftituent parts are from 73 to 85 filver, and from 15 to 25 of fulphur. When raifed to a red heat, the fulphur is gradually fublimed, and the filver appears in filaments, dendritical or reticulated. Many mineralogifts fuppofe that capillary native filver owes its formation very frequently to a fimilar kind of decompofition of vitreous filver-ore. This mineral occurs in veins, and is always accompanied with other ores of filver, and with galena, iron pyrites, brown blende, fulphate of barytes, calcareous fpar, and quartz. It is found in almoft all filver-mines in various parts of the globe.

Brittle vitreous filver-ore; Shrod glaferz, Werner; *Argent noir*, Haüy; differs from the former by its brittlenefs, fplendour, and colour. The colour is intermediate between iron-black and dark lead-grey; it is brightly fplendent externally; internally it alternates from fhining to gliftening; the luftre is metallic. It occurs maffive and differminated, and in thin fmall plates, and frequently cryftallized in fix-fided prifms, varioufly terminated, and in rectangular four-fided tables: the latter cryftals frequently interfect each other, forming the cellular ftructure. The tabular cryftals are generally minute. The fracture of the maffive vitreous ore is uneven; that of the cryftals imperfectly conchoidal. This ore is foft, brittle, and fufible by the blowpipe; the fulphur, arfenic, and antimony, are partly volatilized, and a globule of imperfectly malleable filver, accompanied with a brown fcoria, remains. According to Klaproth, the brittle vitreous filver-ore, from a mine near Freyberg, contained

Silver	- -	66.50
Sulphur	- -	12
Antimony	-	10
Iron	- -	5
Copper and arfenic		0.50
Earthy matter	-	

Black fulphuretted filver-ore; Silber fchwarz, Werner; differs from vitreous filver-ore by its want of luftre: it occurs maffive, corroded, and in powder: the fracture of the former is uneven; the ftreak fhining and metallic. It yields to the knife, and is fufible into a flag, containing globules of filver.

Red filver-ore, or *Ruby filver; Roth giltigerz*, Werner; *Argent rouge*, and *Argent antimonié fulfuré*, Fr. The colours of this mineral are various fhades of red, paffing from a bright-red to dark-red, and reddifh-grey or black. When fcraped, the powder is of a crimfon colour. The cryftallized varieties are tranflucent, or femi-tranfparent, and the tranfmitted light is a carmine, light blood, or cochineal-red. It occurs maffive, differminated, and in thin plates, and cryftallized in hexahedral prifms, varioufly terminated, and in dodecahedrons, with triangular faces, nearly fimilar to the cryftallization of calcareous fpar, called dog-tooth fpar. The primitive form of the cryftal, according to Haüy, is an obtufe rhomboid, whofe plane angles are 104° 28′ and 73° 22′, and the inclination of the faces 109° 28′ and 70° 32′. The fracture is ufually uneven, and imperfectly conchoidal; its luftre externally is fhining and metallic, internally glimmering, fometimes metallic. It is brittle, foft, yielding eafily to the knife. Before the blowpipe it gives out a copious fmoke, with an arfenical fmell, and leaves a globule of filver. Its fpecific gravity is about 5.6. There are feveral minerals which have a red colour, and may at firft fight be confounded with red filver, as the fulphuret of arfenic, or realgar; but this mineral becomes yellow when powdered. Cinnabar has a greater refemblance, but the fpecific gravity is 7, and it is entirely volatilized by the blowpipe. Red oxyd of copper has a fpecific gravity of 3.9, and is ufually accompanied with native copper, malachite, and brown iron ochre; it alfo effervefces with nitric acid, and communicates to a folution of ammonia a blue colour. By thefe characters it may be known from red filver-ore. Werner has divided red filver-ore into two fub-fpecies, the light and the dark. Klaproth analyfed this mineral, and found it to contain only filver, fulphur, antimony, and oxygen. Prouft has fhewn that there are two kinds of red filver-ore, the one containing arfenic, and the other antimony. The conftituent parts, as given by Klaproth and Vauquelin, are

	Klaproth.	Vauquelin.
Silver -	60	54.27
Antimony	20.3	16.13
Sulphur -	11.7	17.75
Oxygen -		11.85
Sulphuric acid	8	

According to the analyſis of Prouſt, a variety of this ore contained nearly .75 parts of metallic ſilver, and .25 of metallic arſenic. Red ſilver-ore occurs in veins, but is always intermixed with other minerals, particularly with compact galena, cobalt, ſulphuret of arſenic, native arſenic, grey copper-ore, and ſparry iron-ore; and has a matrix of calcareous ſpar, ſulphate of barytes, fluor ſpar, or quartz. It is a common ore in ſilver-mines, both in Europe and America: the dark-red ore is conſiderably more productive than the light-red.

Silver amalgam conſiſts of pure ſilver combined with mercury. It has been found in the ſilver-mine of Salberg, in the province of Dalecarlia, in Sweden, in the mines of Deux-Ponts, in the Palatinate, and in ſome other places, either in thin plates or grains, or cryſtallized into octohedrons and dodecahedrons. It is ſometimes ſemi-fluid. Its colour is ſilvery-white or grey, the fracture conchoidal, and the luſtre metallic. It is ſoft, breaks when cut, and whitens the ſurface of gold or of copper; when rubbed upon them warm before the blowpipe the mercury evaporates, and leaves the ſilver pure. The conſtituent parts, given by Klaproth, are

Silver - - - - - -	36
Mercury - - - - -	64

White ſilver ore has a near reſemblance to compact galena. The colour is a light lead-grey, paſſing to ſteel-grey: it occurs maſſive and diſſeminated, and is generally intermixed with cubic galena. The fracture is moſt commonly even, but ſometimes fine-grained and uneven, and alſo fibrous; the internal luſtre is gliſtening and metallic; the ſtreak ſhining. It is ſoft and brittle. The ſpecific gravity is 5.3. Some mineralogiſts think this ore ſhould be claſſed with the argentiferous ores of lead. According to Klaproth, different ſpecimens from Hemmels Furſt, near Freyberg, contain, of the

		Dark-white ſilver-ore.	Light-white ſilver-ore
Lead	-	41	48
Silver	-	9.25	20.40
Antimony	-	21.50	7.88
Iron	-	1.75	2.25
Sulphur	-	22.0	12.25
Alumine	-	1.0	7
Silex	-	0.75	0.25

Carbonate of Silver.—This ore has hitherto been only diſcovered in the ſilver-mine of Wenceſlaus, in Swabia: it occurs ſometimes in maſſes, and ſometimes diſſeminated through other minerals. Its colour is a greyiſh-black; its fracture uneven, with a gliſtening metallic luſtre; it is brittle and heavy, and effervesces with acids; it melts eaſily under the blowpipe. According to Mr. Selb, who firſt deſcribed this mineral, it contains

Silver - - - - -	72.5
Carbonate of antimony -	17.5
Carbonic acid - - - -	12

It contains alſo a ſlight trace of copper.

Beſides the above ores of ſilver, there are ores of other metals which contain a portion of ſilver, and have been claſſed by ſome mineralogiſts with ſilver-ores. An argentiferous variety of grey copper-ore, of an iron-black or ſteel-grey colour, has received the name of black ſilver-ore. It occurs maſſive, diſſeminated and cryſtallized in tetrahedrons; the fracture is ſmall conchoidal, with a ſhining metallic luſtre; it is ſectile and brittle. An ore which is a combination of lead, biſmuth, and ſilver, has received the name of biſmuthic ſilver. Its colour is a light lead-grey: it occurs diſſeminated, but rarely ever in maſſes; the fracture is fine-grained, uneven, with a gliſtening metallic luſtre; it is ſoft and rather brittle; before the blowpipe metallic globules appear on the addition of borax, which unite; the button is brittle, and of a tin-white colour: the flux acquires an amber colour. According to Klaproth this ore contains

Lead	-	-	33
Biſmuth	-	-	27
Silver	-	-	15
Iron	-	-	4.3
Sulphur	-	-	16.3
Copper	-	-	0.9

Argentiferous lead-ores are common in Great Britain and in various parts of Europe. Many of theſe ores are not ſufficiently rich to repay the expence of extracting the ſilver. It is procured in conſiderable quantities in North Wales, the north-weſt parts of Yorkſhire, and in the counties of Durham and Northumberland. Indeed, many lead-ores in theſe counties contain a much larger portion of ſilver than the average proportion of that metal in the ores of Mexico and Peru; but mineralogiſts do not claſs them with ſilver-ores.

Silver Mines in Great Britain.—Silver-ores, properly ſo called, are of rare occurrence in our iſland. A few years ſince, a vein of ſilver was worked with great profit in the pariſh of Alva, in the county of Stirling, in Scotland. The ores were native ſilver, and vitreous ſilver-ore. From forty to fifty thouſand pounds ſterling value was extracted before the ore was exhauſted, after which the ſearch to recover the vein proved fruitleſs, and ſince that time no ſilver-mines have been worked in that country. The ſilver-ores at Alva were accompanied with copper, lead, and cobalt-ores, with a matrix of calcareous ſpar, and ſulphate of barytes. It is ſuppoſed by Dr. Millar that the veins traverſe rocks of argillaceous porphyry.

Cornwall and Devonſhire yield the richeſt argentiferous lead-ores of any part of Great Britain; but the quantity of theſe ores is ſmall. In the former county a ſmall quantity of native ſilver, with other ſilver-ores, have been occaſionally found. We have been favoured with the following account of the preſent ſtate of the ſilver-mines in theſe counties from Mr. Mawe, author of Travels in Brazil, who viſited them in the ſummer of 1815.

From the lead-mines of Ben-Alſten, in Devonſhire, a large quantity of ſilver has been extracted. The vein is ſituated in *killas*, (ſee SLATE,) and is filled chiefly with fluor ſpar and galena. It has been worked to the depth of 110 fathoms: the ſilver extracted from the north and ſouth vein averages about 70 ounces to the ton of lead. Another vein, running in a more eaſterly and weſterly direction, ſituated in the ſame killas, produces 170 ounces of ſilver in the ton of lead. The vein is worked under the river Tamar. Theſe mines are of conſiderable importance; during the laſt ſix weeks, the ſilver extracted from the lead procured here exceeded ſix thouſand ounces. The works are extenſive, and ſaid to be well conducted.

About four miles to the ſouth-eaſt of Callington is a ſilver-mine of another deſcription: the vein is ſituated in a ſimilar rock of killas or chlorite ſlate. The vein was firſt worked for copper, but native ſilver and lead-ore were diſcovered in it. The mine is called Huel Jewel: the thickneſs of the vein rarely exceeds three or four inches. In many of the cavities were found a conſiderable quantity of capillary native ſilver, with galena, red ſilver-ore, and ſulphuret of

silver. The ores were exceedingly rich, and promised at one time an ample recompence to the adventurers.

The Hurland copper-mine, near Redruth, has produced a considerable quantity of native silver in a small vein, branching from the principal vein. Some of the fibres of silver were more than four inches long.

There is a lead-mine near Truro worked at this time, and a considerable quantity of silver is extracted from the lead, as it yields 100 ounces *per* ton.

Near Peranzabula, on the north coast of Cornwall, there was a mine formerly worked close to the sea, which produced lead-ores in various states, and a portion of horn-silver, fine specimens of which are in various cabinets. Mr. Mawe found some specimens of this rare mineral among the refuse of the mine.

At Comb-Martin, in North Devon, are some lead-mines, which were formerly celebrated for the silver, but at present they are not productive.

Argentiferous lead-ores are the common lead-ores of the northern counties and of Wales; they vary in the quantity of silver they contain, from a few ounces to 40, 60, or 80 ounces of silver *per* ton. Some few rare instances have occurred in the north-west part of Yorkshire, of their exceeding the latter amount. On the average, the argentiferous lead that is calcined to extract the silver does not contain 20 ounces *per* ton: by some it has been stated at 17 ounces.

According to Lehman, there are no known lead-ores in the world but what contain silver, except that of Villoch, in Carinthia. (Lehman sur les Mines.) But according to Dr. Watson, the quantity of silver necessary to defray the expence of extracting, and the loss of lead, was nine ounces *per* ton, when lead was at the price of 15*l.* *per* ton. The price of lead is now 26*l.* *per* ton, and though silver be also advanced, yet the difference in the relative prices of each, taking the above as a standard, is such, that to repay the expence of extraction, the lead should contain about fifteen ounces of silver in every ton.

It is not to be expected that the proprietor of any lead-mines rich in silver should be forward in declaring to the world the quantity of silver they contain. The proprietor of the lead-mine containing silver may indeed work the same without any apprehension of its being taken from him under the pretence of its being a royal mine; yet the crown, and persons claiming under it, have the right of pre-emption of all the ore which may be raised. There was an act of parliament passed in the sixth year of William and Mary, entitled, An act to prevent disputes and controversies concerning royal mines. This act declared, that every proprietor of a mine of copper, tin, iron, or lead, should continue in possession of the same, notwithstanding its being claimed as a royal mine, from its containing silver or gold; but it is further enacted, that the crown, or persons claiming under it, should have the privilege of purchasing all the ore which should be raised out of such mine, at the following prices, when made clean and merchantable: for copper-ore, at the rate of 16*l.* *per* ton; for tin-ore, except that of Devonshire and Cornwall, 40*s.*; for iron-ore, 40*s.*; and for lead-ore, 9*l.* The standard price then fixed, particularly for lead, was much higher than the ordinary price of the ore in which there was no silver. Owing to the existence of this act, it is probable that we are not acquainted with the quantity of silver at present extracted annually. We are informed, that the value of silver produced by the lead-mines of colonel Beaumont, in Northumberland and Durham, is not less than 4000*l.* sterling *per annum*; and other large proprietors also extract a considerable quantity of silver from the lead-ores in the northern counties. At present we believe that there is no silver extracted from the Derbyshire lead-ores.

It appears from Hollingshed's Chronicle, that silver was formerly extracted from lead in various parts of the island. In the reign of Edward I. 1600 pounds weight of silver was obtained in the course of three years, from a mine in Devonshire, which had been discovered towards the beginning of his reign: this mine is called a silver-mine by the old writers, but it appears to have been a mine of lead that contained silver. The lead-mines in Cardiganshire have at different periods afforded great quantities of silver: sir Hugh Middleton is said to have cleared from them two thousand pounds *per* month, and to have been enabled thereby to undertake the great work of bringing the New River from Ware to London. The same mines yielded, in the time of Charles I. eighty ounces of silver in every ton of lead, and part of the king's army was paid with this silver, which was minted at Shrewsbury. Sir J. Pettie's Essay on Metal. Works.

A mint for the coinage of Welsh silver had been previously established at Aberystwith; the indenture was granted to Thomas Bushel, for the coinage of half-crowns, shillings, sixpences, twopences, and pennies, and the monies were to be stamped with the ostrich feathers on both sides. In 1604 nearly 3000 ounces of this Welsh bullion were minted at one time at the Tower. Webster, in his History of Metals, published in 1671, makes mention, from his own knowledge, of two places in Craven, in the West Riding of Yorkshire, where formerly good argentiferous lead-ore had been procured. One of the places was Bronghite Moor, in the parish of Slaidburn; the ore held about the value of 67 pounds of silver in a ton: the other was at Skelkhornfield, in the parish of Gisburn; it had formerly belonged to a person of the name of Pudsey, who is supposed to have coined it, as there were many shillings in that country which the common people called Pudsey shillings. There are several smelting-houses at Holywell, in Flintshire, where silver is extracted from lead. According to Mr. Pennant, at one of the largest of these houses in the year 1754, more than 12,000 ounces of silver were produced, but in the subsequent years the quantity of silver appears to have considerably diminished. The silver extracted from lead is sold principally to the manufacturers at Sheffield and Birmingham.

The silver is extracted from the lead by the oxydation of the latter metal in a reverberatory furnace of a particular construction, for the admission of air on the surface of the lead in a state of fusion.

A shallow vessel or cupel is filled with prepared fern-ashes rammed down, and a concavity cut out for the reception of the lead, with an opening on one side for the mouth of the bellows, through which the air is forcibly driven during the process. The French smelters cover the surface of the ashes with hay, and arrange symmetrically the pieces of lead upon it. When the fire is lighted, and the lead is in a state of fusion from the reverberation of the flame, the blast from the bellows is made to play forcibly on the surface, and in a short time a crust of yellow oxyd of lead, or litharge, is formed, and driven to the side of the cupel opposite to the mouth of the bellows, where a shallow side or aperture is made for it to pass over; another crust of litharge is formed and driven off, and this is repeated in succession till nearly all the lead has been converted into litharge and driven off. The operation continues about forty hours, when the complete separation of the lead is indicated by a brilliant lustre on the convex surface of the melted mass in the cupel, which is occasioned by the removal of the last crust of litharge that covered the silver. The French introduce water through a tube into the cupel, to cool the silver rapidly and prevent

its ſpirting out, which it does when the refrigeration is gradual, owing probably to its tendency to cryſtallize. In England the ſilver is left to cool in the cupel, and ſome inconvenience is cauſed by the ſpirting, which might be avoided by the former mode.

The ſilver thus extracted is not ſufficiently pure; it is again refined in a reverberatory furnace, being placed in a cupel lined with bone-aſhes and expoſed to a greater heat: the lead which had eſcaped oxydation by the firſt proceſs is converted into litharge, and abſorbed by the aſhes of the cupel.

The laſt portions of litharge in the firſt proceſs are again refined for ſilver, of which it contains a part that was driven off with it. The litharge is converted into lead again, by heating it with charcoal; part is ſometimes ſold for a pigment, or converted into red lead. The loſs of lead by this proceſs differs conſiderably, according to the quality of the lead. The litharge commonly obtained from three tons of lead amounts to 58 hundred weight; but when it is again reduced to a metallic ſtate it ſeldom contains more than 52 hundred weight of lead, the loſs on three tons being about eight hundred weight. The Dutch are ſaid to extract the ſilver from the ſame quantity of lead, with a loſs of only ſix hundred weight.

Silver-Mines of France.—The mine of Allemont, ten leagues from Grenoble, in the department of Iſere, is ſituated near the ſummit of a mountain, compoſed of thin beds of mica-ſlate and hornblende, curiouſly contorted and broken. Its elevation is about 3000 yards above the level of the ſea. The veins are numerous, and run in all directions: the mineral appears to have filled alſo numerous fiſſures in the rock. The ores are native ſilver, vitreous ſilver, red ſilver-ore, and horn-ſilver. Silver appears alſo diſſeminated in a kind of ferruginous clay, and is accompanied with various ores of cobalt, antimony, arſenic, and nickel. The matrix was ferruginous clay and carbonate of lime, mixed with aſbeſtus, epidote, and calcareous ſpar. The veins were much richer near the ſurface than at a great depth, and the working of this remarkable mine is at preſent nearly abandoned. Red ſilver-ore has alſo been found in the Voſges, in the department of the Upper Rhine, in a vein of argentiferous copper-ore. Indications of ſilver have been traced in other diſtricts of France. The lead-ores of ſome parts of France are alſo ſufficiently rich in ſilver to repay the expence of extraction.

The *ſilver-mines of Spain* are the moſt ancient known in Europe. It appears, as well from the accounts of hiſtorians, as from the numerous veſtiges of ancient workings, that the operations were carried on to a conſiderable extent. The moſt remarkable mine was that at Guadalianel, in Andaluſia, in the Sierra Morena, five leagues to the north of Seville; the ore which it contains is the red or ruby ſilver, in a matrix of compact galena. Since the diſcovery of South America no attention has been paid to the mines of Spain, though formerly ſo productive both of ſilver and gold.

Germany.—The mining diſtrict of Freyberg, in Saxony, contains numerous veins that yield ſilver. The veins that traverſe rocks of gneiſs are generally compoſed of quartz, calcareous ſpar, and fluor ſpar; they incloſe argentiferous lead, vitreous ſilver-ores, ruby ſilver, and grey argentiferous copper-ore. The mine at Annaberg, according to Klaproth, contains muriate of ſilver (horn-ore) mixed with much clay, which is imbedded in compact lime-ſtone. The mines of Schneeberg, in Miſnia, and of Hartz, in Hanover, contain argentiferous lead, accompanied with proper ſilver-ores.

Hungary.—The mines of Schemnitz and Cremnitz, in Hungary, have been long celebrated, both for the richneſs of their productions and the immenſe extent of the operations. The rocks in which the mining operations are carried on, are deſcribed as being compoſed of an argillaceous grey-ſtone, mixed with quartz or ſchorl, or particles of calcareous ſpar. To this rock baron Born has given the name of the metalliferous rock, *ſaxum metalliferum:* it is deſcribed by him as containing three principal veins, running from north to ſouth, and parallel with the river Gran, following even the windings of the river. From this circumſtance we ſhould infer, that the river itſelf had originally taken the courſe of a fracture by another vein. The dip or inclination of all the veins is from weſt to eaſt, varying from 30 to 70 degrees. In one part of the vein, called the *ſpitaler vein*, it is joined with an argillaceous white vein, which runs along with it on the *hanging* ſide, and from the place of junction the vein is found to contain ſilver. In this white clay are occaſionally found nodules of ſpar and maſſes of quartz, which yield from four to five ounces of ſilver in the hundred weight. The ſecond great vein at Schemnitz has nearly the ſame characters as the firſt. The third great vein is more irregular in its inclination, and the ores are not ſo rich in ſilver, but in ſome parts it contains a conſiderable quantity of gold.

Some notion may be formed of the extent of the mining operations at Schemnitz, from the gallery or level called the Emperor Francis' Gallery, by which the whole of the royal mine is drained and cleared of water. This gallery, which forms a very conſiderable excavation, and is carried through hard rock, was a work of immenſe labour and difficulty; it is five Engliſh miles in length: it was begun in 1748, and finiſhed in 1765.

The mountains round Kremnitz, according to baron Born, are compoſed of the ſame metallic rock already deſcribed; but according to Patrin, they conſiſt of primitive trap. At this place very extenſive operations, which were begun at leaſt a thouſand years ago, have been eſtabliſhed on a large and rich gold vein, and ſome of its branches. The rock is a white ſolid quartz, mixed with fine auriferous red and white ſilver-ore, and with auriferous pyrites. At the depth of 160 fathoms, the vein continued rich and productive.

Konigſberg is another mining-town of Hungary, ſome miles to the north-weſt of Schemnitz. The valley in which this place is ſituated is bounded on one ſide by the ſame kind of metallic rock, and on the other, towards the north, by granite mountains. In the royal mine, at the time it was viſited by baron Born, the vein was obſerved to run between the metallic rock, which formed its *hanging* ſide, and the granite, which was its *lading* or lower ſide. The vein is grey quartz, mixed with auriferous pyrites. The firſt ſteam or fire-engine eſtabliſhed in the Lower Hungarian mines was erected at Konigſberg, in 1725, by Iſaac Porter, an Engliſh engineer, who was then in the imperial ſervice.

Bohemia.—The circle of Saatz, in Bohemia, abounds in various metallic ores, among which the ores of ſilver occaſionally predominate. The prevailing rocks are gneiſs and argillaceous ſchiſtus. The veins at *Catharineberg* traverſe gneiſs, and generally run in a north and ſouth direction, and parallel to the mountain in which they are ſituated. But there are alſo ſome powerful veins which croſs the mountain. One of this nature is deſcribed, which ſeems to be inſenſibly blended with the mountain rock. The vein-ſtone is alſo of the ſame kind of rock, but occaſionally aſſuming the characters of a variety of granite. It is obſerved, that the vein, which ſeldom exceeds a foot in width, diminiſhes in thickneſs when the containing rocks become harder; and when the ſides are found incruſted with a ferruginous clay, it appears to be richer in ores. Fiſſures from the ſides of the vein are found to improve it: a fine white clay, with

quartz imbedded in it, indicates rich ore; but a coarse clay, destitute of quartz, especially when it increases in quantity, and occupies the whole vein, renders it unproductive, or entirely barren. The ores of the vein now described are rich silver and copper pyrites, with fluor spar, blende, various copper-ores, and sometimes native silver and copper.

Joachimsthal, a place in the same circle, has been long celebrated on account of its valuable mines. The prevailing rocks are described as grey micaceous and quartzose clay-slate, which at a great depth became more of an argillaceous nature, soft, foliated, and of a black colour. The mountains around this place have a gentle declivity towards the south, but run in lofty ridges to the east, north, and west, and are intersected by deep vallies. This inequality of surface affords great accommodation to the miners to open numerous galleries, which converge to the south, and to the valley in which stands the town of Joachimsthal. All the galleries and works of this district are divided into six different fields, belonging to the same number of companies, and they are drained by two deep drifts or levels; the one of which runs in a direct line 1600 fathoms; but including its several branches, its whole length is 4500 fathoms. The depth under the highest tops of the mountain is 170 fathoms: the second great level, which runs through the space of 5600 fathoms, and in a direct line 1500 fathoms, is 20 fathoms deeper than the first; but the operations in the mines have been carried to a much greater depth; for at the time in which they were visited by Ferber, before 1774, the perpendicular depth under the surface was from 200 to 350 fathoms, and, excepting the mines in the Tyrol, were then considered as the deepest in the world.

The thickness of the veins varies from one inch to two feet; and the vein-stones are a whitish or blueish clay, argillaceous slate, and reddish horn-stone, or petro-silex, which is the matrix of the richest ores. The silver-ores which are found in this mining district are, native silver, which is attached to different vein-stones, and assumes various forms; vitreous silver-ore, which is dug out sometimes in very large masses, and is considered as a very rich ore; one hundred weight being commonly valued at 180 marks of silver: red silver-ore, sometimes beautifully crystallized and transparent, is attached to red horn-stone or calcareous spar; and white silver-ore has sometimes but rarely appeared.

The silver-mines of *Berestadt*, in the circle of Tabor, are in hills of a gentle declivity, and composed of grey or blueish clay-slate, in which appear figures of greenish lithomarge, or semi-indurated pot-stone. These mines were formerly rich in native silver, and other ores of that metal. A vein to the west of this place, which traversed a hard rock, contained reddish-coloured felspar, with galena, blende, and a little silver; but from the part where a vein containing white arsenical pyrites came into the hanging side, the vein produced native silver, vitreous, red, and white silver-ore. Another vein in the same place, which is from two inches to one foot in width, is observed to be richest where it is thinnest. It is chiefly enriched by an undulating black clay fissure, which appears sometimes in the hanging side, and then it produces red and white silver-ore. When crossed by veins running from east to west, it appears to be cut off and barren, till beyond the place of junction it again becomes productive in its former course.

Sweden.—The silver-mines of Salberg, in Westmania, are about 28 English miles from Upsal. The ore is an argentiferous galena, yielding from one marc to a marc and a half of silver *per* quintal; it is in compact lime-stone, and has been worked to the depth of 150 fathoms. The average profits amount to about 4000*l*. and one-eighth is paid to the king. Porter's Travels.

Norway.—The silver-mines of Konigsberg, in Norway, are situated in mountains of moderate height, composed of nearly vertical beds of mica-slate with garnets, and of grey quartz mixed with fine black mica, and a little lime-stone and red horn-stone. Other beds are composed of a ferruginous rock, which, in the upper part of the mine, is 33 feet thick, but in the lower not more than 6 feet thick.

The veins are from half an inch to two feet or more in thickness, and cut the strata transversely. The matrix of the ore is granular lime-stone, sometimes intermixed with fluor spar. Enormous masses of native silver have sometimes been found in this mine; one is mentioned as weighing 220lbs. The common ores are native silver and vitreous silver. The veins are most productive in the ferruginous rock. The annual produce is about 5000lbs. weight of silver.

Asia.—The silver-mines of Zmeof are situated in that part of the Altaian chain of mountains which lies between the Oby and Irtisch, from 50° to 52° north latitude. The annual produce has been stated at 60,000 marcs of silver, which is alloyed with about 3 *per cent*. of gold. The mines of Nertschink in Daouria, near the river Amur, yield argentiferous galena, producing about 30,000 marcs of silver, and containing $1\frac{1}{12}$ *per cent*. of gold. The Russian merchants who trade to China bring back ingots of silver, from several ounces to a pound weight, in exchange for their commodities; hence it may be inferred, says Patrin, that there are silver-mines on the frontiers of China. Patrin, Hist. des Mines.

America.—The most productive silver-mines in the world are those of South America and New Spain. Those of Peru, for many years after its conquest by the Spaniards, yielded the greatest quantity of silver; but at present the mines of Mexico are the richest. The mines of America furnish both silver and gold; and in making an estimate of their richness, we must take an account of each of these metals. The following table, given by M. Humboldt, will shew the distribution of these mineral treasures in the different parts of the new world; the kilogramme being 2 lbs. 3 oz. 5 dr. avoirdupois, or rather more than 2 lbs. 8 oz. troy.

	Gold.	Silver.
Viceroyalty of Peru - -	782	140,478
Viceroyalty of New Spain -	1,609	537,512
Capitania of Chili - -	2,807	6,827
Viceroyalty of Buenos Ayres -	506	110,764
Viceroyalty of Grenada - -	4,714	
Viceroyalty of Brasil - -	6,873	
Kilogrammes	17,291	995,581

The above was the annual produce of the different districts, at the beginning of the 19th century; from which it appears, that the total weight of the precious metals from all the mines in America, reduced to English pounds troy, is 45,580 lbs. of gold, and the enormous quantity of 145,000 lbs. of silver; equal in weight to one-third of the tin produced by the mines in Europe. Dr. Adam Smith, in his "Wealth of Nations," values the gold and silver annually exported into Cadiz and Lisbon at only six millions sterling, including not only the registered gold and silver, but that which may be supposed to be smuggled. This estimate is only two-fifths of the real annual amount.

The mountain of Potosi has furnished, since its discovery in 1545, a mass of silver equal in value to 234,093,840*l*.

fterling. The mountain is 18 miles in circumference: it is compofed of flate, but has a conical covering of porphyry, which gives it the form of a fugar-loaf, or bafaltic hill; it rifes 697 toifes, or 480 yards, above the furrounding plain. The richnefs of the veins has diminifhed, as they have been worked to greater depths. At the furface of the earth, the veins of Rica, Centeno, and Mendicta, which traverfe primitive flate, were filled with native filver, and filver-ores throughout their whole extent. Thefe metallic maffes rofe in ridges or crefts above the furface, the fides of the vein having been deftroyed either by water or by fome other caufe. In 1545, minerals containing from 80 to 90 marcs of filver *per* quintal were common. In the year 1574, according to Acofta, the average richnefs of the ore was eight or nine marcs *per* quintal. In 1607, the mean wealth of the ores was not more than an ounce and a half to the quintal. The ores are now extremely poor, and it is on account of their abundance alone that the works are ftill in a flourifhing ftate: for from 1574 to the year 1789, the mean quantity of filver in the ores has diminifhed in the proportion of 170 to 1; while the abfolute quantity of filver extracted from the mines of Potofi has only diminifhed in the proportion of 4 to 1.

About fix miles from Pafco is the mountain Jauvichora: it is diftinguifhed by the name of the Silver mountain. It is about half a mile in diameter, and only about 30 yards in depth: it is compofed of brown iron-ftone, which is interfperfed with pure filver. This ftone does not yield more than nine marcs of filver in 500 lbs.; but there is a friable white clay met with in the middle of this mafs of ore, which yields from 200 to 1000 marcs of filver in every 50 cwt. The mountain is penetrated in all directions, without any attention to fecurity; fo that it is expected it may fall in, in the courfe of a few years. According to Helms, this mountain yields annually 200,000 marcs of filver.

The veins of filver at Potofi are in flate, which Humboldt confiders as primitive: this flate is covered with a clay porphyry, containing garnets. The mines of Gualgayoc, in Peru, are in the Alpine lime-ftone. The veins which furnifh nearly all the filver exported from Vera Cruz are in flate, porphyry, grauwacke, and Alpine lime-ftone: the principal of thefe veins are thofe of Guanaxto, Zacatecas, and Catoree. The vein of Guanaxto yields more than one-fourth of the filver of Mexico, and a fixth part of the total produce of America. This vein is, in fome parts, from 147 to 150 feet in width, including the branches, and has been wrought from Santa Ifabella and San Bruno to Buena-Vefta, a length of 42,000 feet. The moft celebrated mines in Mexico are elevated from 6000 to 9000 feet above the level of the fea. In the Andes, the mines of Potofi, Ocuro, Pas, Pafco, and Gualgayoc, are in regions higher than the loftieft fummits of the Pyrenées. A mafs of rich filver-ore has been difcovered near the fmall town of Micuicampa, at the abfolute height of 13,450 feet. The great elevation of the Mexican mines is peculiarly advantageous to the working of them, as the climate is temperate, and favourable to vegetation and cultivation.

The part of the Mexican mountains which at prefent contains the greateft quantity of filver, lies beween the twenty-firft and twenty-fourth degrees of latitude; and it is not a little remarkable, that the metallic wealth of Peru fhould be placed at an almoft equal latitude, on the other fide of the equator. In the vaft extent which feparates the mines of La Pas and Potofi from thofe of Mexico, there are no others which throw into circulation a great mafs of the precious metals, but thofe of Pafco and Chota. The ifthmus of Panama and the mountains of Guatimala contain, for a length of 600 leagues, vaft tracts of ground, in which no vein has hitherto been worked with fuccefs.

The province of Quito, and the eaftern part of the kingdom of New Granada, from the eighth degree of fouth latitude to the feventh degree of north, are equally poor in metallic wealth. It would not, however, fays Humboldt, be correct to infer that thefe countries, which have been convulfed and torn by volcanoes, are deftitute of the precious metals. Numerous metallic repofitories may be concealed by beds of bafalt, and other rocks of fuppofed volcanic origin. It fhould, however, be remarked, that fome of the rocks, which Humboldt enumerates as very metalliferous, are by other geologifts confidered of volcanic origin, particularly clink-ftone-porphyry, and other porphyries containing hornblende, but diftinguifhed by the abfence of quartz and common felfpar.

The mines of Huantajya are celebrated for the great quantities of native filver they formerly produced. They are fituated in an arid defert, and furrounded by rock-falt, near the fhores of the Pacific ocean, at no great diftance from the fmall port of Yquique, in the audience of Lima. Thefe mines are a remarkable exception to the great elevation of filver-mines in Spanifh America, being placed on a low and gentle declivity. Their produce is native filver, vitreous filver, and horn filver; the annual amount is about 50,000 lbs. troy of filver, or 80,000 marcs.

The filver-mining operations of Chili, according to Humboldt, are in general not productive; but the vein at Ufpalata contains *pacos* fo rich, that the produce is from 2000 to 3000 marks in every 5000 lbs., or from 40 to 60 marcs *per* quintal. Molina, in his Hiftory of Chili, defcribes the vein at Ufpalata, on the Andes, as being nine feet in thicknefs. It has been traced 90 miles, and is fuppofed to extend 300 miles. From the main vein there are branches on each fide, which extend to the neighbouring mountains: fome of thefe branches are 30 miles in length. This is the largeft metallic vein which is at prefent known in the world.

According to Humboldt, the greateft part of the filver extracted from the bowels of the earth in Peru is furnifhed by a fpecies of ore called the pacos, of an earthy appearance, which M. Klaproth analyfed, and was found to confift of almoft imperceptible particles of native filver with the brown oxyd of iron. In Mexico, on the contrary, the greateft quantity of filver annually brought into circulation is derived from vitreous filver-ore, grey filver-ore, horn-ore, and black and red filver-ores. Native filver is not extracted in fufficient quantity to form any confiderable proportion of the total produce of the mines of New Spain. It is, fays this traveller, a very common prejudice in Europe, that great maffes of native filver are very common in the mines of Mexico and Peru, and that in general the mines of mineralized filver, deftined to amalgamation, or to fmelting, contain more ounces, or marcs of filver, to the quintal, than the filver-ores of Saxony or Hungary; but he adds, I was furprifed to find that the number of poor mines greatly exceeds thofe of the mines which, in Europe, would be efteemed rich. It is at firft difficult to conceive how the famous mine of Valenciana, in Mexico, can regularly fupply 30,000 marcs of filver *per* month, as the vein confifts of fulphuretted filver, diffeminated in almoft imperceptible particles through the matrix. In the formation of thefe veins, it fhould appear that the diftribution of filver has been very unequal, being fometimes concentrated at one point, and at other times diffeminated in the vein through the matrix or *gangue;* for, in the midft of the pooreft ores

are found confiderable mafles of native filver. Although the new continent has not hitherto produced fingle mafles of native filver equal to what have been found in the old, the metal is more abundant in a ftate of perfect purity in Mexico and Peru than in any other quarter of the globe, not in mafles, but in particles diffeminated through the enormous quantity of the ore called pacos. The refult of a general inveftigation of the richnefs of different mines is, that the mean richnefs of the different ores is not more than from three to four ounces of filver in every fixteen hundred pounds of ore. According to this refult, the ore contains, on the average, two ounces and two-fifths *per* quintal. It had formerly been afferted, that no ores were worked in Mexico that did not contain one-third part of filver. The filver-ores of Peru are not richer on the average than thofe of Mexico. The diftrict of Guanaxto has before been mentioned as furnifhing more than one-fourth of the filver annually extracted in America, the riches of the mines here being fuperior to the celebrated repofitory at Potofi: they are all worked in one extenfive vein. Among thefe mines, that of the count Valenciana is one of the richeft: the average produce of filver is four ounces of filver from a quintal of ore.

The whole weight of filver from the vein of Guanaxto, on an annual average from 1786 to the year 1803, has been 556,000 marcs, or 364,911 lbs. troy; and in thirty-eight years the weight of gold and filver, from the fame vein, has been 12,700,000 pounds troy. In average years it yields from 500,000 to 600,000 marcs of filver, and from 1500 to 1600 marcs of gold. It has been doubted by fome perfons whether this be really a vein, or a metallic bed, as in fome parts of its courfe it is parallel between the beds, or ftrata of the rock. It pafles through both flate and porphyry, and is metalliferous in both. Though it has been before ftated that the extent of this vein is more than 42,000 feet; yet the enormous mafs of filver which it has fupplied for the laft hundred years, fufficient alone to change the price of commodities in Europe, has been extracted from an extent of lefs than 2000 feet; for where this vein is not widened by branches, its general width may be ftated at from 38 to 48 feet. It is for the moft part feparated into three mafles, divided by banks of mineral matter, or by part of the matrix deftitute of ore.

At Valenciana the vein continues undivided to the depth of 557 feet, and then divides into three branches; and its width, from the floor to the roof, is from 164 to 196 feet. Of thefe three branches of the vein, there is in general only one which is rich in metals. Sometimes, when thefe three branches unite, the mine is uncommonly rich. In this celebrated vein there is a certain middle region, which may be confidered as a repofitory of greater riches, for above and below this region the ores are poor in filver.

At Valenciana the rich minerals have been in the greateft abundance, 300 and 1100 feet below the mouth of the gallery.

The labour of the miner is entirely free throughout the whole kingdom of Spain, and no Indian or Meftizoe can be fined to work in the mines. The Mexican miner gains from 1*l.* to 1*l.* 4*s.* fterling *per* week of fix days. The men employed in agriculture do not gain more than a third of that fum. The miners work nearly naked, and are fearched in the moft indelicate manner on leaving the mine. They frequently conceal fragments of native filver and filver-ores in their hair, under their arm-pits, in their mouths, and even in the anus, into which they force cylinders of clay containing the metal. Thefe cylinders are called *longanas*. A regifter is kept of the filver found in different parts of the body. In the mine of Valenciana, the value of thefe ftolen minerals, a great part inclofed in the longanas, amounted, from the year 1774 to 1787, to 30,000*l.* fterling.

The filver is extracted from its ores in New Spain by amalgamation with mercury, and by fmelting: the proportion of filver extracted by mercury is $3\frac{1}{2}$ to 1 of that extracted by fmelting; and as fuel is becoming fcarce, the quantity of filver extracted by amalgamation increafes, the fmelting being very imperfectly conducted.

The Mexican miners do not appear to follow any fixed principle in the felection of minerals deftined to fmelting or amalgamation; for in one diftrict they fmelt the fame ores, which in another they believe can only be managed with mercury; and it is frequently the abundance or fcarcity of mercury which determines the miner in the choice of his method. In general they fmelt the argentiferous galena, and the mixed minerals of blende and vitreous copper. The *pacos*, the vitreous, red, and corneous filver-ores, the grey copper-ore rich in filver, and the meagre ores, diffeminated in fmall quantities in the matrix, they find it more profitable to amalgamate.

All the metallic wealth of the Spanifh colonies is in the hands of individuals. The government poffefles no other mine than that of Huanca Velica in Peru, which has been long abandoned. The individual receives from the king a grant of a certain number of *meafures*, on the direction of a vein or bed; and they are only held to pay very moderate duties on the minerals extracted. Thefe duties have been valued on the average throughout all Spanifh America at $11\frac{1}{2}$ *per cent.* of the filver, and three *per cent.* for the gold. In the fpace of a hundred years, the annual produce of the Mexican mines has increafed from twenty-five to one hundred and ten millions of francs. The produce of the mines in Peru has of late years been rather decreafing, which Humboldt attributes to its being worfe governed than Mexico. The procefs of extraction feems alfo to be conducted upon worfe principles than in New Spain, though in neither of thefe diftricts is fmelting, or amalgamation, performed with much fkill; for, according to M. Humboldt, the quantity of mercury annually confumed in New Spain exceeds two million one hundred thoufand pounds troy. The mercury is feparated from the amalgam by diftillation; but in the whole procefs, the Mexicans wafte eight times more than would be neceffary, were the procefs conducted in the fame manner as at Freyberg.

The following table will fhew the annual produce of gold and filver in the mines of Europe, northern Afia, and America, as given by M. Humboldt, in kilogrammes. It may be regarded rather as an approximation to the real amount, than as a very accurate ftatement, the amount of Englifh filver not being included; perhaps this may be eftimated at 4000 lbs. troy.

	Gold.	Silver.
Europe - -	1,297	52,670
Northern Afia -	538	21,709
America - -	17,291	795,581

The kilogramme, it has been before ftated, is rather more than 2 lb. 8 oz. troy. It is impoffible to value the quantity of gold and filver annually extracted on the whole globe; for we are unacquainted with the amount of what is procured in the interior of Africa, and the central parts of Afia, Tonquin, China, and Japan. The quantity of gold and filver formerly brought by the Dutch from the latter country proves that it is rich in the precious metals. We may draw the fame conclufion refpecting the northern frontiers of China and other parts of Afia; and the quantity of

gold-duſt brought to the weſtern coaſt of Africa, leads us to believe, that the countries ſouth of the Niger contain large quantities of this metal, though we have little information reſpecting the ſilver of the African continent.

Aſſay and Analyſis of Silver-Ores.—Pure native ſilver requires no other aſſay than fuſion, with a little potaſh to free it from its earthy matter. In the humid way the ſilver may be diſſolved in nitric acid, and precipitated by common ſalt. The precipitate may then be fuſed with ſoda in a crucible, by which the ſilver is obtained pure, and the muriate of ſoda ſublimed. The auriferous ſilver-ores may be treated with potaſh, by fuſion in a crucible: the alloy of ſilver and gold is firſt obtained, and the two metals may be ſeparated by the proceſs of parting. See Refining and Assaying.

Thoſe ores which conſiſt of ſilver combined with antimony or arſenic, or both, are firſt roaſted, to drive off the arſenic and antimony, the ſilver remaining pure. The proceſs is much facilitated by the uſe of nitre, for the purpoſe of oxydating the metals to be diſſipated.

The humid analyſis of this ore requires more particular treatment.

The ore commonly called arſenical is firſt to be coarſely powdered, and then diſtilled vinegar poured upon it, to diſſolve the lime of the calcareous ſpar adhering to it.

A given quantity of the ore ſo waſhed is now to be finely powdered, and nitric acid poured upon it: this oxydates the metals, diſſolving the greateſt part, and leaving a yellowiſh reſiduum. To the part diſſolved muriate of ſoda is to be added, which precipitates the ſilver. This precipitate being waſhed and dried, will give 77 *per cent.* of pure ſilver. To the liquid from which the laſt was precipitated add a ſolution of potaſh; a lightiſh red precipitate is now formed, which, on drying, becomes of a deep brown, and by ignition aſſumes the form of powder of a whitiſh-grey colour: this is the arſeniate of iron. This ſubſtance contains iron and arſenic, in the proportions of 50 to 43 or 44. This is ſhewn by treating the arſeniate of iron with charcoal expoſed to a red heat; the arſenic is reduced, and ſublimes, while the black oxyd of iron remains.

The yellowiſh reſiduum left in the firſt ſolution is to be digeſted with muriatic acid: if a white powder remains undiſſolved, it will be found to be muriate of ſilver, and muſt be added to that firſt obtained. To the muriatic ſolution add a ſolution of carbonate of potaſh, and a yellowiſh-green precipitate is formed: to this precipitate, when waſhed and dried, add muriatic acid by a little at once, till the powder is diſſolved; add a large quantity of water to this ſolution, which will produce a white precipitate; this being ſeparated and dried will be pure oxyd of antimony, affording $\frac{16}{21}$ of pure antimony. What remains in ſolution, after the laſt ſubſtance is ſeparated by the water, may be precipitated by pure potaſh, and will be found to be oxyd of iron; which, when treated with charcoal, like the firſt obtained, may be added to the ſame to make the whole of the iron afforded by the mineral. In this way the arſenical ſilver-ore afforded, according to Klaproth, the following analyſis:

Silver	- -	12.75
Iron	- -	44.25
Arſenic	- -	35
Antimony	-	4
		96

The ſulphuretted ores in the large way ſometimes merely require to be roaſted to drive off the ſulphur: the heat being urged affords a button of pure ſilver. This is the caſe with the variety called *Silver-glance.*

The brittle ſilver-ore contains a very ſmall portion of antimony and copper. The metallic button obtained by heat will require to be cupelled with lead, in order to get the ſilver pure; it may, however, be made tolerably pure by treating the button with nitre, by which the baſe metals are ſeparated.

To effect the humid analyſis of brittle ſilver-ore, the powder is diſſolved in dilute nitric acid with a gentle heat. By this treatment a reſiduum is left equal to $\frac{26}{100}$ of the whole. The ſolution is to be treated with muriate of ſoda, like the laſt.

If the preſence of an alkaline ſulphate does not form any precipitate with the remaining ſolution, the mineral does not contain lead: add to the ſolution an exceſs of ammonia, and a greyiſh-white precipitate will be left, which is the oxyd of iron, often containing a little arſenic. If copper be preſent, ammonia will give to the remaining ſolution a fine blue colour, and that metal may be ſeparated by a rod of clean iron.

It now remains to examine the firſt reſiduum which was unaffected by the nitric acid; this is to be digeſted with nitro-muriatic acid: the reſiduum left after this treatment will be found to be pure ſulphur. The nitro-muriatic ſolution is now to be diluted with a large quantity of water; a white precipitate falls down, which, when waſhed, dried, and ignited, will be found to be oxyd of antimony, of a brown colour.

Klaproth found 100 grains of this ore to yield as follows;

Silver	- - - - -	66.5
Antimony	- - - - -	10
Iron	- - - - -	5
Sulphur	- - - - -	12
Copper and arſenic	- - -	.5
Extraneous matter from the mine	-	1
		95

The white ſilver-ores afford nearly the ſame ingredients with the laſt; and the mode of analyſis will be ſimilar in the dry way.

The *light-white* and *dark-white* ſilver-ores contain lead and alumine, and require a different treatment. After the ſilver is precipitated by common ſalt, a quantity of muriate of lead is formed at the time, which, on concentration, affords the muriate of lead in bright ſilky cryſtals. When theſe are collected till the liquid will afford no more, a ſolution of ſulphate of ſoda is to be added, which precipitates the remainder of the lead in the ſtate of ſulphate of lead. This powder, being waſhed and dried, contains $\frac{5}{7}$ths its weight of metallic lead. The remaining liquid being ſuperſaturated with ammonia, as in the analyſis of the brittle ſilver-ore, a light-brown precipitate is formed: this precipitate is oxyd of iron and alumine. To ſeparate the latter, diſſolve the precipitate in nitric acid: ſeparate the iron by pruſſiat of potaſh, or pruſſiat of lime, and afterwards the alumine with ſoda. The pruſſiat of iron, heated to a red heat, is decompoſed, leaving the black oxyd of iron, which contains $\frac{50}{64}$ of metallic iron.

The firſt reſiduum left by the nitric acid, beſides antimony and ſulphur, which conſtituted the reſiduum of the brittle ſilver-ore, alſo contains lead. By the frequent addition of muriatic acid with the application of heat, the lead is ſeparated in cryſtals of muriate of lead; obtaining, by this means, a ſolution of the muriates of lead and anti-

mony. The reſiduum is ſulphur. The muriatic ſolution depoſits cryſtals of muriate of lead on cooling. When no more cryſtals fall down, theſe cryſtals are to be added to thoſe obtained before. Theſe, being heated in an aſſay crucible with twice their weight of black flux, afford metallic lead. This lead, however, treated in the uſual way on the cupel, affords a ſmall portion of ſilver. The ſolution ſtill contains a ſmall portion of muriate of lead and the antimony. By adding a ſolution of Glauber's ſalt, the lead is precipitated in the ſtate of ſulphate, affording $\frac{5}{7}$ths its weight of metallic lead. The antimony, which is the laſt, may be precipitated by affuſion of water. The precipitate, being waſhed, dried, and ignited, is the pure oxyd of antimony, yielding on its reduction $\frac{90}{77}$ of the metal. The analyſis of the light white ſilver-ore, by Klaproth, gives of

Silver - - - - -	20.4
Lead - - - - -	48.06
Antimony - - - - -	7.88
Iron - - - - -	2.25
Sulphur - - -	12.25
Alumine - - -	7
Silex - - -	0.25
	98.09

The dark ſilver-ore, by the ſame, is

Silver - - - - -	9.25
Lead - - - - -	41
Antimony - - - -	21.5
Iron - - - -	1.75
Sulphur - - - -	22
Alumine - - - -	1
Silex - - -	.75
	97.25

The corneous ſilver-ore, which is muriate of ſilver, is eaſily reduced in the dry way by fuſing it with ſoda, in a crucible capable of fuſing the metallic ſilver. The ſoda takes the muriatic acid, forming muriate of ſoda, which eſcapes in white fumes, and the ſilver is left pure.

In the humid way, it is firſt fuſed in a glaſs retort with carbonate of potaſh. The maſs is then diſſolved in hot water, and the ſolution filtered. The reſiduum is then diſſolved in nitric acid, leaving behind a red powder. This powder, being treated with nitromuriatic acid, leaves behind a ſmall portion of muriate of ſilver, which muſt be accounted for in metallic ſilver, as before directed. Ammonia, being added to the nitromuriatic ſolution, precipitates a red powder, which is oxyd of iron. To the nitric ſolution, from the maſs firſt treated with carbonate of potaſh, muriate of ſoda is now to be added; which precipitates the ſilver in the form of muriate, from which the metallic ſilver may be either calculated, or obtained by fuſion with ſoda. The aqueous ſolution from the fuſed maſs is now to be ſaturated with acetic acid. If alumine be preſent, it will be precipitated. The liquid part is now to be evaporated to dryneſs. If alcohol be added to the dry maſs, it diſſolves the acetate of potaſh. The reſiduum is then diſſolved in water. To this, muriate of barytes is to be added, which, if ſulphuric acid be preſent, will cauſe a precipitation of ſulphate of barytes, the ſulphuric acid of which is to be conſidered as a product of the ore, and will be equal to one-third of the weight of this precipitate, when waſhed and dried. The remainder of the ſaline maſs which was diſſolved in water may be conſidered as muriate of potaſh, the acid of which is another ingredient of the analyſis, and will be equal to $\frac{11}{35}$ of the ſalt.

Phyſical and Chemical Properties of Silver.—Silver, when pure and newly poliſhed, is of a ſplendid white colour, and becomes more white when the poliſh is deadened. Its hardneſs is nearly that of copper. Its malleability is nearly equal to that of gold. At a heat viſibly red in the dark, it can be worked with great facility by the hammer into various articles, in the manner of working iron. After being rolled into very thin ſheets, it can be beaten into leaves of $\frac{1}{100000}$th of an inch in thickneſs, and can be drawn into wire finer than a human hair. A wire of $\frac{1}{12}$th of an inch will require 336 lbs. to break it, when exerted in the direction of its length. At a temperature ſhort of redneſs, theſe pieces can be united either by the hammer, or by preſſing them together with friction by a ſteel burniſher.

It melts at the temperature of 28° of Wedgewood, or 4717° of Fahrenheit. If the heat be raiſed the metal becomes more liquid, and boils. This is occaſioned by its aſſuming the elaſtic form, in which ſtate it riſes, and is condenſible on the ſurface of bodies held over it, as has been obſerved with gold.

In purifying ſilver on the cupel, it is obſerved, that when it is removed from the furnace, and juſt at the point of congelation, a ſmall exploſion enſues, giving to the ſurface of the button an appearance as if ſome elaſtic fluid had been diſengaged from it. It has been diſcovered by Mr. Samuel Lucas, of Sheffield, that the elaſtic fluid which is ſeparated, producing the phenomenon in queſtion, is pure oxygen gas.

By keeping ſilver long in a ſtate of fuſion, at a very high temperature, it becomes oxydated.

Macquer converted ſilver into a vitreous oxyd by expoſing it to the heat of a porcelain furnace.

Silver is readily inflamed by electricity, and converted into an oxyd of a greeniſh-yellow colour.

The moſt direct way to obtain the oxyd of ſilver is by diſſolving the ſilver in nitric acid, and precipitating it with lime-water. The precipitate is at firſt white, in which ſtate it may be conſidered a hydrate of the oxyd. When heated, the water eſcapes, and it aſſumes a greeniſh-yellow colour, inclining to grey. If the heat be raiſed, the air being excluded, the oxygen is drawn off, leaving the metal in a ſtate of purity: 100 parts of ſilver have been found to contain 7.5 of oxygen; hence, if the atom of hydrogen be 1, that of ſilver will be 100. No combination of ſilver with azote or carbon has as yet been diſcovered.

It combines with ſulphur with great facility: the mere contact of the metal with flour of ſulphur is ſufficient to give the ſurface a yellow colour. If the ſilver be in thin plates, and ſtratified in a crucible with the ſame, at a red heat the combination ſoon takes place, and the maſs fuſes, forming a ſulphuret of ſilver of a violet colour, ſometimes in cryſtals of the ſhape of a needle.

This ſubſtance is brittle, but ſufficiently ſoft to be cut with a knife. It is decompoſable by heat. The ſulphur eſcapes, leaving the metal in a ſtate of purity. This compound is an atom of ſilver equal to 100, united to an atom of ſulphur 15.

Sulphuret of ſilver is alſo formed by expoſing the metal to ſulphuretted hydrogen gas. The ſmall quantity of the latter exiſting in the atmoſphere is capable of ſoon communicating a yellow, and ultimately a purple colour to poliſhed ſilver.

Mr. Proust found this tarnishing matter to be a sulphuret of silver. The thinnest coat of gum, or of varnish, completely defends the surface of silver from tarnishing.

Silver combines with phosphorus, forming a phosphuret of silver. This combination is effected by heating in a crucible equal parts of silver and phosphoric glass, with one-fourth their weight of charcoal powder, or, what is better, saw-dust. This compound is of a white colour. It is brittle, but may be cut with a knife. It is, like the sulphuret, decomposable by heat.

Silver combines with several metals, forming alloys. The alloy of silver with gold, when the former is in a very small quantity, is of a much paler colour than gold. These, like all other compounds, are doubtless definite, and hence we should expect, that when these metals combine in the ratio of the weights of their atoms, which will be 100 silver to 140 of gold, the alloy would be the most perfect. And the next perfect would be two atoms of one to one of the other. It is stated by Muschenbroeck, that the hardest alloy of these two metals is with two parts of gold to one of silver.

Silver, as well as rendering gold much paler, gives it a greenish tinge. This alloy is more fusible than gold, and hence is employed as a solder for that metal.

Silver does not form any striking alloy with platinum. Indeed it rather appears to be a mixture than a combination. As is the case with lead and zinc, the two metals separate, when kept some time in a state of fusion. This fact is corroborated by the circumstance, that silver can scarcely be made to unite two pieces of platinum together, when used as a solder, while gold can be employed for that purpose with the greatest success. For the other alloys of silver, see the respective metals.

Salts of Silver.—These consist of the oxyd of silver combined with an acid, some of which only are soluble in water. The presence of the soluble salts of silver is easily detected by muriatic acid, or any soluble saline compound with that acid, by occasioning a dense white precipitate, which soon changes to a purple colour when exposed to the sun's light.

The insoluble salts of silver have the property of coating bright copper with silver, when rubbed upon it with a little moisture. Salts of mercury would give the same white appearance, but this would be distinguished from silver by being capable of dissipation by heat. Salts of silver become black with the hydro-sulphurets of the alkalies. And gallic acid gives a brown precipitate.

Sulphate of Silver.—Sulphuric acid has no action upon silver at the common temperature. When, however, this metal is boiled with the acid, the silver becomes oxydated, sulphurous acid gas is disengaged, and sulphate of silver is formed, which is a white mass, sparingly soluble in water, except an excess of sulphuric acid be present. The latter, on evaporation, affords crystals of a brilliant silvery whiteness, in the form of needles or fine prisms.

This salt is soluble in nitric acid.

When heated, it first fuses, and if the heat be raised, it is decomposed, sulphuric acid and oxygen escaping, leaving the silver in its metallic form.

This salt is decomposed by the alkalies and earths, and all those soluble salts, the acids of which form insoluble compounds with silver. Bergman has stated, that 100 parts of metallic silver, precipitated from nitric acid by sulphuric acid, give 134 of the sulphate. Allowing the 100 of silver to have taken 7 of oxygen, there will remain 28 for the sulphuric acid. This, in 100, will give sulphuric acid 22, and 78 of oxyd of silver. If this salt be composed of one atom each of acid and base, then, by Dr. Wollaston's scale, the proportions would be 25.5 acid, and 74.5 oxyd of silver. Dalton's numbers would give very nearly the same result.

Sulphate of Silver.—This salt, like the last, is sparingly soluble in water. In other respects, it is but little known.

Nitrate of Silver.—The nitric acid acts with considerable violence on silver, affording red suffocating fumes, occasioned by the copious disengagement of nitric oxyd. If the acid and the silver be pure, the solution becomes clear and colourless, without residuum: if the acid contains muriatic acid, which is often the case with the acid of the shops, then a dense white powder will fall down, which becomes purple in the sun-shine, and is the muriate of silver: if the silver contains gold, a purple powder will be left at the bottom of the vessel: if it contains copper, the solution will be of a green colour, of greater or less intensity, depending upon the quantity of that metal.

The solution of silver affords crystals on evaporation; they are of a prismatic form, but differ in their number of sides; they do not change by exposure to the air, but are very soluble in water. These crystals, when heated, first melt; the heat being raised, the water of crystallization escapes, but the mass still remains liquid: in this state it is frequently cast into moulds, in which it assumes a solid form on cooling. These sticks, which are employed in surgery under the name of *lunar caustic*, are of a grey colour, and when broken exhibit a crystalline appearance.

A more violent heat than that required for its fusion decomposes it, nitrous gas and oxygen being disengaged.

This decomposition is much more rapid when it is heated in contact with inflammable matter. If thrown upon burning coals, it detonates.

If silk, cotton, leather, ivory, and many other bodies, be moistened with nitrate of silver, and the part be afterwards moistened, when a stream of hydrogen gas is applied to it the silver becomes reduced, and appears with its metallic lustre. A stick of phosphorus dipped in nitrate of silver soon becomes coated with metallic silver.

This salt has the property of detonating with sulphur or phosphorus, by being struck smartly with a hammer.

Nitrate of silver is decomposed by all the earths which form salts, and by the alkalies, by combining with the acid. Ammonia, however, does not only precipitate the oxyd, but afterwards combines with it, forming a compound having alarming fulminating properties. The following is the process recommended for its preparation.

From the nitrate of silver precipitate the oxyd by means of lime-water: separate the oxyd, and dry it upon blotting-paper: upon this oxyd pour pure caustic ammonia: let this remain for twelve hours. If a pellicle be formed upon the surface, add a little more ammonia, which will take it up. A black precipitate will be found at the bottom of the vessel, which is the ammoniate of silver, and is the fulminating substance to be obtained. This precipitate is to be carefully collected, and laid in very small quantities upon separate bits of blotting-paper, to dry. When dry, the slightest touch or rubbing motion causes a violent explosion. Those unaccustomed to it should begin with the smallest possible quantities, as serious accidents have happened by exploding it in too large quantities. The liquid part from which the substance was separated will be found to be a solution of the same: if it be heated in a glass retort, a portion of it is decomposed, and the gaseous products disengaged: in a little time, small brilliant crystals of the same substance appear:

these frequently detonate with such violence, as to break the vessel in which they are contained.

The theory of these appearances is obvious: the oxygen of the silver combines with the hydrogen of the ammonia, forming water, which, with the azotic gas of the same, are in an instant rendered so highly elastic by the caloric set free, as to produce the explosive effect so conspicuous in this substance. It is needless to say that the silver is left in the metallic form.

Nitrate of silver is decomposed by all those metals having a superior attraction for oxygen. The oxygen of the silver is given to the decomposing metal, which also combines with the acid. Copper, so employed, precipitates the silver in a white metallic powder, the result being nitrate of copper in the place of nitrate of silver. The precipitate is not pure silver, some copper will always be detected when the precipitate is re-dissolved.

Mercury has also the property of precipitating silver from the nitrate, producing the appearance which has been termed the *arbor Dianæ*. Lemery recommends one part of silver to be dissolved in nitric acid, and the solution to be then diluted with twenty parts of distilled water: to this add two parts of mercury. The mercury gradually occupies the place of the silver, and the latter is precipitated in the form of vegetation, from which the name has been derived.

The vegetative appearance is caused by the growth of the crystals being from the extreme points of that already formed, as is the case with the growth of vegetables. The mercury, and the smallest portion of precipitated silver, form a Galvanic combination. The silver now in solution is reduced upon that already formed, in consequence of its state of electricity being negative, that of the mercury being relatively positive, by which it attracts the acid. This process would doubtless be facilitated by dropping a small bit of metallic silver upon the mercury, added to nitrate of silver. This would form a Galvanic combination, and the bit of silver would become an immediate rallying point for the silver in solution. If a little of a dilute solution of nitrate of silver be spread upon a pane of glass laid in an horizontal position, and a common pin be laid in the middle of the covered part, in a few hours, beautiful ramifications of silver extend from every side of the pin; sometimes to the distance of an inch. This is also to be explained by Galvanism.

Muriate of Silver.—When muriatic acid, or any soluble muriate, is added to nitrate of silver, a dense and blueish-white precipitate is thrown down, which is muriate of silver. Although white when it is just precipitated, it soon assumes a purple tint by exposure to the light, and the change is quicker as the light is more intense: hence this substance has been employed to measure the degree of intensity of light, by the time in which the change of colour takes place.

It may be said to be insoluble in water: this property, and its conspicuous appearance in other respects, renders the nitrate or sulphate of silver so valuable as a test for muriatic acid. The latter, on combining with the silver, forms the salt in question.

When this salt is exposed to heat, it easily melts: on cooling, it becomes solid. It is a semi-transparent mass, of a grey colour, and of a horny appearance, from which it has been called *luna cornea*, or horn-silver. If fused with a great heat in a crucible, it becomes so thin a fluid as to sink through the pores of the crucible. It is not decomposed by any of the acids, nor the alkalies, but when heated with the carbonates of potash or soda, the acid is disengaged. It dissolves in caustic ammonia, forming a transparent solution: this, by exposure to the air, undergoes considerable change. A pellicle forms on the surface, which is first of a blueish colour, and ultimately black. This pellicle, on examination, is found to be muriate of ammonia and reduced silver. Those who with sir Humphrey Davy hold oxymuriatic acid to be a simple body under the name of chlorine, consider this substance as a compound of the latter substance with metallic silver. Sir Humphrey gives it the name of *argentane*, and Dr. Thomson, more consistently, *chloride of silver*.

The composition of this salt, according to Proust, is

Muriatic acid	-	18
Oxyd of silver	-	82

By the atomic theory it should be constituted by 100 + 7.5 = 107.5 of oxyd of silver, and 24 muriatic acid, which would give

Oxyd of silver	-	81.7
Muriatic acid	-	18.3

Sir Humphrey considers it as a compound of one proportion of chlorine, 67, and one proportion of silver, 205, which will give

Silver	- - -	75.3
Chlorine	- -	24.7

Considering the 24.7 of chlorine as oxymuriatic acid, which would be 18.8 muriatic acid, and 5.9 oxygen; then giving this oxygen to 75.3 of silver, would give 81.2 of oxyd of silver, and 18.8 of muriatic acid in the 100, which nearly agrees with the above. The property which this salt has of becoming black by the action of light, has rendered it useful for marking linen. Very improper ingredients have been sold for this purpose. The nitrate of silver is employed to write with upon the linen, which is very proper; but the part is often prepared by a solution of soda or potash, instead of a solution of muriate of soda (common salt). The following will be a recipe which cannot fail of success: dissolve 30 grains of lunar caustic in one ounce of distilled water; this will be for the writing liquid. For the preparing liquor, dissolve half an ounce of common salt in four ounces of water; and in the same dissolve half an ounce of gum arabic. Moisten the part to be marked with the latter, and dry it till the writing will not run. The letters will first appear of a blueish-white, but become perfectly black by exposure to light.

The fluate, borate, phosphate, carbonate, and arseniate of silver, are insoluble powders, having no striking properties, or but little known. The arseniate is formed by adding arseniate of potash to any soluble salt of silver. It falls down in the form of powder of a yellow colour. Its insolubility, and its conspicuous colour, have been taken advantage of by employing nitrate of silver as a test for arsenic.

The chromate of silver is an insoluble salt, of a red colour; it is formed by adding chromate of potash to nitrate of silver. It, however, becomes purple by exposure to air and light.

Acetate of silver is a soluble salt, formed by adding the acetic acid to oxyd of silver. The solution affords prismatic crystals.

The rest of the salts are but little known.

Silver, in *Medicine*, is called *luna*, the moon; and has been much extolled for its virtues by chemical writers. But

crude filver, however comminuted or attenuated, has not been obferved to produce any medical effect. It is not foluble in any of the fluids of the animal or vegetable kingdom.

Several preparations have been made from filver; particularly a

SILVER *Pill*, or *Pilula Lunaris*, which is a chemical preparation of filver, formerly highly commended as an anthelmintic, and as a purgative remedy for dropfies, and in many other inveterate ulcerous difeafes.

The method of making it is this: diffolve an ounce of pure nitre in diftilled water; then diffolve an ounce of cryftals of filver, made in the common way, with pure filver and aqua fortis, in three times the weight of water, fo that the folution may be perfectly limpid: mix the two folutions together, they will become a clear homogene liquor; evaporate this to a pellicle, and cryftals refembling nitre will fhoot; pour off the remaining nitre as before, and the remaining nitre will fhoot with the filver, in form of cryftals, again, upon a fecond evaporation: let thefe cryftals be dried upon a paper, and then placed in a glafs veffel in a very gentle heat, enough to make them fmoke, but not run; ftir it with a piece of glafs all the time, and keep it over the fire, till no more fumes arife; thus the acid fpirits will be driven off, and the filver remain of a very bitter tafte and purging quality. It muft be kept in a dry clofe veffel.

This difcovery has been made to ferve to many other purpofes, befides its ufes in medicine, and has furnifhed the difhoneft pretenders to alchemy with one of their moft cunning methods of deceit. They have been able, by this means, to conceal filver in nitre, and that in a very large proportion, as in one-tenth part of the whole quantity; and this nitre being projected in an equal quantity on melted lead, gives an increafe of one-tenth part in filver, which remaining upon the teft, will deceive the ignorant, as if a tenth part of the lead were converted into pure filver. People who are upon their guard, may, however, difcover the cheat, by diffolving the pretended nitre in ten times its weight of water, and putting a polifhed plate of copper into the folution; for every particle of the filver will then be precipitated out of the liquor upon the copper, and to the bottom of the veffel.

The medicinal ufe is this: the dried mafs, confifting of the falts of filver and nitre, is to be reduced to a fine powder: this powder, applied to ulcers, acts in the manner of the lapis infernalis, or filver-cauftic, only much milder: but for internal ufe, the quantity of two grains of it is to be ground to a fine powder, with fix grains of loaf-fugar, in a glafs mortar; this is to be then mixed with ten grains of the crumb of bread, and formed into nine pills: thefe are to be taken by a grown perfon upon an empty ftomach, drinking after them four or fix ounces of hot water, fweetened with honey. It purges gently, and brings away a liquid matter like water, often unperceived by the patient. It is faid to kill worms, and perform great things in many obftinate ulcerous diforders. It purges without griping, but it muft not be ufed too freely, nor in too large a dofe, for it always proves weakening, and in fome degree corrofive on the ftomach; but this inconvenience is greatly alleviated by rob of juniper. Boerh. Chem. part ii. p. 297.

However, with this affiftance, it is at beft a dangerous medicine, and as fuch is defervedly excluded from practice. Lewis.

SILVER, *Tincture of*, is made by diffolving thin filver plates, or filver fhot, in fpirit of nitre; and pouring the folution into another veffel full of falt-water. By this means, the filver is immediately precipitated in a very white powder, which they wafh feveral times in fpring water. This powder they put into a matrafs; and pour rectified fpirit of wine, and volatile falt of urine, upon it. The whole is left to digeft in a moderate heat for fifteen days; during which, the fpirit of wine affumes a beautiful fky-blue colour, and becomes an ingredient in feveral medicines. This is alfo called *potable filver, argentum potabile*.

Silver is likewife converted into cryftals, by means of the fame fpirit of nitre; and this is called *vitriol of filver*.

The lapis infernalis argenteus is nothing but the cryftals of filver melted with a gentle heat in a crucible; and then poured into iron moulds. See CAUSTIC, *Lunar*.

Addenda and corrigenda

PRINTING, Calico, is the art of imparting various colours to plain calicoes, in any form, or according to any pattern that may be desired, by means of certain colourless mordants previously applied to the cloth. This art has sometimes been denominated *topical* dyeing, and the various branches of it are calculated to astonish those who may have the opportunity of witnessing the different processes, without being acquainted with the nature of chemical mordants, and their several uses in the arts.

The art of calico-printing is of great antiquity. Homer speaks of the variegated cloths of Sidon, as having a very splendid appearance; and Pliny describes the Egyptians as accustomed to prepare parti-coloured linens, and observes that these colours were produced after a manner corresponding with our method of topical dyeing. He says the Egyptians began by painting or drawing on white cloths, (doubtless linen or cotton,) with certain drugs, which in themselves possessed no colour, but had the property of attracting or absorbing colouring matters. After which, these cloths were immersed in a heated dyeing liquor; and though they were colourless before, and though this dyeing liquor was of one uniform colour, yet when the cloths were taken out of it soon after, they were found to be wonderfully tinged of *different* colours, according to the different natures of the several drugs, which had been applied to their different parts; and these colours, so wonderfully produced from a tincture of only *one* colour, could not afterwards be discharged by washing; and he considers it as admirable, that the dyeing liquor, which, if cloths of different colours had been put into it, would have confounded them all, should thus produce, and permanently fix *several* colours, being itself only of one colour. Pliny, lib. xxxv. cap. 2.

This account contains so plain a description of one of the branches of calico-printing, that no one who is conversant with the present practices can entertain any doubt but that the ancient Egyptians were acquainted with many of the principles of this very curious art. Our readers, who are desirous of further investigating this interesting subject, will find abundant and satisfactory information by consulting the following works: *viz.* Pliny's "Natural History;" the 26th volume of "Recueil des Lettres Edifiantes, &c." Strabo, lib. xv.; Delaval's "Experimental Inquiry into the Cause of Change of Colours, in opaque and coloured Bodies;" Berthollet's "Elements of the Art of Dyeing," vol. i. p. 28; Beckman's "History of Inventions," in 4 vols. 8vo.; Mr. Parkes's "Chemical Essays," vol. ii. p. 65, &c.; and Dr. Bancroft "On Permanent Colours." In the above works, abundant testimonies will be found to shew that printed calicoes were not unknown to the ancients; and we have good reason also to suppose that the colours which they imparted to their cloths possessed a considerable degree of permanency, as we know that iron and alum were both employed by them as mordants. It is likewise well known that several ancient nations were acquainted with soda, madder, tin, the juice of the *buccinum*, cochineal (or an insect similar to it), the celebrated Tyrian purple, and other materials, sufficient in the whole to enable them to give a great variety of colours and tints to their several productions.

Our object, however, in this communication, is to give a succinct account of the art of calico-printing as it is conducted at present, and we do not know that we can do better than to copy the greater part of the detail which has been given by Mr. Parkes in his "Essay on Calico-Printing," in the second volume of his "Chemical Essays," and which he has very politely allowed us to make use of in any way we think proper.

From this essay it appears, that calico-printing, as an art, is but of modern date in this country, though it has been practised in India, and other parts of the East, from time immemorial. From various accounts it appears, that formerly in India the cotton cloths when brought from the weavers, partly bleached, were worn next to the skin by the dyer and by all his family, during the space of eight or ten days, after which they underwent several macerations in water, with goat's dung, and were afterwards submitted to frequent washings, and as frequent dryings in the rays of an intense sun-shine. Afterwards they were soaked for some time in the mixture of the astringent fruit of the yellow *myrobalans*, and of curdled buffalo's milk. When thoroughly impregnated therewith, they were squeezed, dried by exposure to the sun, and then, by pressure and friction, they were made smooth enough for being drawn upon by the pencil with the different mordants.

The first of these mordants was an iron liquor, made by dissolving iron in a mixture of four palm-wine and of water in which rice had been boiled. This liquor was applied to the figures or spots intended to become black, and afterwards the aluminous mordant was applied, commonly by children, with the pencil, to the parts intended to be made red. The pieces were then exposed to the hottest sun-shine, that the parts to which the mordants had been applied might be dried as much as possible: and then they were thoroughly soaked in pits of water, to cleanse them from the superfluous mordants, as well as from the buffalo's milk, &c.: and lastly, they were dyed in water, with certain roots answering nearly in their effects to those of madder.

It was in this way the manufacture of printed cottons

was conducted by the Indians in *former* times. The following is an account of the *modern* Indian practice, in one particular branch of their manufacture, which Mr. Parkes says he procured from a gentleman who had spent some time in India, and who had taken pains to inquire into their manipulations.

This process relates to the method of printing the fine cotton chintz counterpanes, which the natives call *pallampoors*, and which are manufactured at Madras. These are woven in one piece, from two to four yards square, and are printed, or rather painted, with various designs, and in various colours. Their method is to draw a pattern first on sheets of paper sewn together, of the size of the intended pallampoor; and then to prick out the same in the paper with a sharp instrument. This done, the paper pattern is smoothly fixed upon the cloth, which is previously damped, and a small muslin bag containing some kind of black powder is rubbed over the whole, in order to pass a part of the powder through the pin-holes, and completely mark out the pattern.

The pattern being thus sketched upon the cloth, the paper is removed; and when the outline of the various figures is drawn with a pencil, the piece is considered to be ready for receiving the colours.

One colour is then laid on with a brush made with a tough root of a particular kind of tree, or with the husk of the cocoa-nut; and when this is dry, the piece of cotton is given to a woman to wear, or to use in the family, till it be very much dirtied; in order that it might necessarily undergo a thorough washing, which is thought requisite to prove the goodness and permanency of the colour. Another colour is then laid on in the same manner, and the piece is again submitted to the same trial of wearing and washing. The Asiatics may not be aware of it; but doubtless the long exposure to the air in these cases is the important point, as it is well known that the atmosphere is a prime agent in rendering many colours permanent, which, under a different treatment, would be heavy and fugitive. This is repeated for every colour that is employed;—and when any one of these colours is found to be deteriorated by this treatment, it is printed afresh; and so are all the rest, till the workman is satisfied that all the colours are actually permanent.

This tedious process is adopted, however, only when the manufacturer means to warrant the article; but in all cases, even in those pieces which will not bear washing, the colours are laid on by a brush, as before mentioned.

Whether they are all substantive colours which are thus applied, or whether they use any species of mordants in their fast work, we are unacquainted, as the artists of India observe great secrecy, and are extremely jealous on this subject.

Such are the facts which we have been able to collect respecting the progress of calico-printing from the earliest ages; and also of the present state of the art among the Asiatics. The more difficult part now remains, *viz.* to give a brief detail of the most important processes of our own artists. This, however, we shall endeavour to do with the utmost plainness, and shall not fail to suggest any improvement that may have occurred to us during our inquiries respecting this very interesting and varied branch of manufacture.

We have not been able to ascertain when calico-printing was introduced into this country, though there are various reasons for believing that it is an art, among us at least, but of modern date.

As the whole of this ingenious business, as it is now conducted, depends upon the proper application of a few compounds called *mordants*, it will be necessary, in the first place, to explain their nature and uses. In doing this, one or two preliminary remarks will assist us.

The colouring substances chiefly employed in this art are divided into two classes, *viz. substantive* and *adjective*. A *substantive* colour is one which is capable of itself of producing a permanent dye on wool or woollen cloth; such is the juice of the buccinum, used by the ancients for producing the imperial purple; such are also the woad and indigo employed by the moderns for producing a permanent blue; and we may add the metallic solutions, particularly those of iron, cobalt, gold, platina, and silver, which give various colours, according to the processes by which they are prepared.

It has been proposed to employ this valuable permanent colour for pencilling on fine muslins. In time of peace it might readily be procured in sufficient quantities, and would prove an important addition to the resources of the British calico-printer.

Dr. Bancroft tells us, that the first mention of indigo, as known in England, is in the Act of the 23d of queen Elizabeth, chap. 9, where it is called *Ancle*, or *Blue Inde*. Bancroft on Permanent Colours, p. 138.

By *adjective* colours are meant all those which are incapable of giving permanent dyes without the aid of certain intermedia, which form as it were a bond of union between them and the substances intended to be dyed.

These intermedia are what are known by the term *mordants*, and are used for this purpose in very considerable quantities by the calico-printer of the present day.

Several expedients of this kind were employed by the ancients to produce fast, or, more properly, permanent colours, and this appears from the testimony of Aristotle and Pliny. The chief articles in use at present are, the acetate of iron, the acetate of alumine, and the various solutions of tin, all of which should be very carefully and correctly prepared.

We have already given some account of chemical mordants in vol. XXIV. part 1, under the article MORDANTS; which see.

When piece-goods are designed to be dyed of one uniform adjective colour, they are first immersed in a solution of one of these mordants, then hung up to dry, and to absorb the oxygen of the atmosphere. When sufficiently exposed to the air, they are washed or dunged, to remove the superfluous mordant; that is to say, that part of it which is not chemically combined with the cloth; and the goods are then submitted to a bath of that particular kind of colouring matter which is to be imparted to them.

The dung of the cow is used in such large quantities by the calico-printer, that it has become an article of great expence. The proportion that is employed is usually about one bushel to one hundred gallons of water, though frequently a larger proportion would be more effectual. The brightness of the colours, and the purity of the whites, are always dependent upon the quantity of the dung employed.

Whenever it is meant that the colour should be partially inserted, the mordant is applied to those particular parts only; so that, when the piece is immersed in the colouring bath, no other place will receive the permanent stain. If a sufficient number of colouring substances should ever be discovered, that have no affinity for any thing but the chemical mordants, the business of calico-printing would be rendered much more easy and simple than it is at present. For though the whole texture of the cloth will be coloured,

yet having in itſelf no affinity with the vegetable with which the decoction is impregnated, the whole of the colouring matter will be eaſily removed by expoſure to the air, and the ground of the piece reſtored to its original whiteneſs; while thoſe parts to which the mordant was applied, will retain and fix the colours in a way which will be more fully explained hereafter.

Formerly all calico-printers were bleachers; but in the neighbourhood of London theſe are ſeparate and diſtinct trades, and the printer either purchaſes bleached goods for printing on his own private account, or receives the cloth from his cuſtomers in a white ſtate; and, when printed, he returns the identical pieces, and is paid ſo much *per* yard, according to the number of colours, for printing them.

In our opinion every printer ſhould bleach his own goods, for it is impoſſible always to rely with confidence on the care of thoſe who bleach for hire; and every printer knows that good bleaching is abſolutely a neceſſary preliminary in the production of good printing. Indeed, this is now pretty generally acknowledged in the north of England; for moſt of the opulent houſes in Lancaſhire and in Scotland, which produce fine work, are bleachers as well as printers.

Oxymuriate of lime is the agent generally employed in bleaching; but it appears to us that ſome other article might be introduced with advantage. For, as the goods are waſhed in diluted ſulphuric acid when they are taken from the oxymuriate of lime, a ſulphate of lime is always formed, which becomes fixed in the fabric, and, acting as a mordant when the pieces come into the madder-copper, occaſions an indelible ſtain, which in very fine goods often impairs their beauty. If oxymuriate of ſoda were employed, the ſulphuric acid would form a ſoluble ſalt with the ſoda, eaſily removable by waſhing.

No people have taken more pains to excel in bleaching than the Iriſh, and their credit is eſtabliſhed accordingly. The German linen, we believe, is generally better than theirs; but the Iriſh has always the preference in foreign markets, owing to their ſuperiority in bleaching and finiſhing.

A very minute account of the various proceſſes in bleaching has been already given in our 4th vol. part ii. under the article BLEACHING; which ſee.

By whatever means the bleaching is performed, the printer commences his part of the buſineſs in the following manner.

The goods are firſt *dreſſed* by ſingeing off the whole of the nap which is attached to them. This is effected by the following contrivance:—Ten pieces are generally wired together, and wound upon a roller, from whence they are paſſed over a hot iron, nearly in the form of half a cylinder, and received upon another roller; from thence they are returned to the iron, which is ſtill kept red, or nearly at a white heat. The uſe of repeating this proceſs is to remove the nap more effectually than it would be done by paſſing it only once over.

The next operation is that of *ſteeping*, which conſiſts merely in ſoaking the pieces for twenty-four hours in a veſſel of weak alkaline ley, at a temperature of about 100°. Theſe operations of ſingeing and ſteeping are going on at one and the ſame time, which effectually prevent any accident that might otherwiſe ariſe from the effects of the hot iron.

The goods are then boiled or elſe bowked in a ſolution of potaſh (ſome workmen prefer to have this alkali in a pure cauſtic ſtate); they are then well cleanſed by thorough waſhing in waſh-wheels, or in ſtocks, to enſure their being entirely diveſted of the alkali. The intention of thus treating them with potaſh, is to remove any greaſe or impurity that may be attached to them, which would otherwiſe endanger the evenneſs and uniformity of the colours. This proceſs is called *aſhing*.

By ſome obſervant calico-printers it has been imagined, that the rendering of the ley cauſtic is apt to impair the texture of the cloth; and we doubt not but that this has often been the caſe. Under the eye of the maſter, however, we are ſure that it might be employed with advantage and ſafety.

It may be remarked, that in weaving calicoes the workman generally greaſes the reeds, in order to make them move eaſier. Tallow is alſo employed for dreſſing the warp, and this has a baneful effect on all goods which are deſigned for printing. Wherever this greaſe is in the cloth, it becomes fixed by the operation of ſingeing; and if it be not taken out before bleaching, it will not come out afterwards by the uſual proceſs of aſhing and ſouring; for, when the pieces are ſubmitted to a blue vat to be dyed of a uniform ſelf-colour, all thoſe greaſy places will be found to have taken the dye in a very imperfect manner. If the calico-manufacturers themſelves would make a point of preparing the oleaginous matter for the weavers, and would furniſh them with nothing but pure vegetable oils, ſuch as thoſe of rape, linſeed, &c., it is very likely that theſe inconveniences would not occur; for the ſtain from *vegetable* is not ſo indelible as that from *animal* oil. To cleanſe ſuch goods, various expedients have been adopted, but we apprehend nothing but a ſolution of cauſtic alkali can be depended upon. To prove the effect of any method which may be tried, it is a good way to run the pieces through water, and then to paſs them from the water ſo gradually over a roller, as to give the ſuperintendant an opportunity of examining every inch of the ſurface; and if any part remains greaſy, it will be ſeen at once, for that part will continue dry, while all the reſt of the cloth is wet.

There is another way in which the goodneſs of bleaching might be proved. Let a few of the ſuſpected pieces be run once or twice through a madder-copper, at the temperature of about 180°. This will inevitably mark any part that may be imperfectly bleached; whereas, if the operation has been properly performed, they will come out ſo little ſtained, that an intelligent workman, who has been uſed to a madder-copper, will at once be ſatisfied that they contain no impurity that can form a permanent mordant.

The next proceſs is one with diluted ſulphuric acid. A quantity of ſoft water having been poured into a leaden veſſel, oil of vitriol is gradually added to it, in the proportion of about twenty pounds of oil of vitriol to every hundred gallons of water, which by weight is in the proportion of about one to forty.

When this mixture has been well ſtirred, it is ready for uſe. Sometimes it is employed in this ſtate, at others it is heated to 90° or upwards of Fahrenheit, according to the nature of the work to be done, and the goods are immerſed in it. They are not ſuffered to lie in this ſolution, but are wound by means of a winch over a wooden cylinder, that every part of the cloth may be immerſed in the fluid, and expoſed alternately to the action of the atmoſphere.

This operation is generally continued for about twenty minutes, and is deſigned to remove any iron-moulds or other ſtains which the cloth may have acquired. It has alſo the effect of neutralizing any portion of potaſh that may have been left in contact with the cloth. The proceſs is called *ſouring*.

After this operation it is neceſſary to waſh the goods thoroughly, that no part of the acid may be left in them to injure their texture, and this is beſt effected by means of

the wafh-wheel. The calicoes are then to be regularly and thoroughly dried, which finifhes thefe preliminary operations, known in the trade by the term *preparation;* fo that thofe cloths which have paffed through thefe manipulations are faid to have undergone a preparation. Befides the ufes already mentioned, there is another advantage attending thefe proceffes, *viz.* that the cloth which has undergone this preparation will bleach fooner, the colours will be brighter, and the whites more delicate, than they would have been had they not gone through thefe previous operations.

The next procefs is that of *calendering*. Here the goods are paffed through a fet of rollers, which gives them a glofs, and the appearance of their having been ironed. They are now fit for printing. For copper-plate printing, or cylinder work, the procefs of calendering is omitted.

In printing faft colours, the artift ufually proceeds in this way: he lays the piece of calico, which has been already fmoothed by calendering, upon a ftrong thick table, which is previoufly covered with a woollen cloth. He then proceeds to apply one or more mordants, as the cafe may require, for fixing the intended colours. Thefe mordants are applied by means of wooden blocks, with the patterns formed upon them. Thefe blocks were formerly chofen of holly, and the cutting them was a feparate branch of the bufinefs, and was called *block-cutting*. Of late years, however, a confiderable improvement has been made in this part of the bufinefs by the introduction of brafs or copper; that is, the pattern, inftead of being actually cut in the wood, is now formed by means of flender pieces of one of thofe metals being firmly fixed to the block, fo as to produce the pattern intended. This alteration was occafioned by the perifhable nature of wood, on account of which every printer incurred great and unneceffary expence. The pattern when thus formed with copper, is not only more lafting, but it has alfo the advantage of giving greater fharpnefs and beauty to the impreffion. When it was cuftomary to ufe wooden blocks, the patterns were not enchafed in the wood, but the wood was cut away in fuch a manner as to leave the pattern in relief. It will be obvious that this muft always be the cafe in *block*-printing.

When the mordant is ready, it is mixed up either with flour-pafte, or with a thick aqueous folution of gum arabic, gum fenegal, or gum tragacanth, and is then fpread upon a piece of fuperfine woollen cloth, ftrained tight upon a hoop. This is placed within another hoop, covered either with fheep-fkin or oil-cloth. Thefe hoops are both fo broad as to give to each of them the appearance of a tambarine. That which is covered with the woollen cloth is called a *fieve*, the other a *cafe*. The fieve within its cafe is now placed in a fmall tub of gum-water, and is ready for ufe.

Flour is an article of confiderable confumption with the printers for making pafte. Some houfes buy twenty barrels of American flour at once. Should it be mufty or four from keeping, it is of little confequence for their ufe; but they are careful to buy none but fuch as has been made with found wheat, for if unfound it will be of no value for their purpofes.

Gum tragacanth is much dearer than the other gums mentioned above; but notwithftanding this, it muft be had for fome ftyles of work, as no other will anfwer for any of thofe colours or mordants which are prepared with nitrous acid. A folution of gum fenegal would be coagulated in an inftant by any of thofe preparations. Of late years, an article called Britifh gum has alfo been much in ufe for the fame purpofe; fo much fo that the making of it has become a diftinct trade. It is merely common ftarch pulverized, and then calcined till it affumes a cinnamon-brown colour.

When the apparatus is thus prepared, the mordant is applied by a brufh to the furface of the fieve. This is called *teering*.

It fhould have been remarked, that when a colourlefs mordant, like the acetate of alumine, is employed, the workman generally mixes a little of the decoction of Brazil wood, or of any other fugitive dye, with it. This is called *fightening;* and is for the purpofe of making the pattern more obvious to the workman, that he may fee its progrefs, and the efficacy of the materials, as he proceeds in printing. The manipulation may be thus defcribed.

Taking the block containing the pattern in one hand, the workman applies it gently to the furface of the fieve, fo that a fufficient quantity of the thickened mordant may adhere to the figures. When the block is thus charged, he applies it to the calico, and gives it a blow with a fmall mallet, either flightly or otherwife, according to the nature of the pattern.

This alternate application of the block to the fieve and to the calico, is continued till the workman has gone over the whole piece. In this way, feveral different mordants are fometimes applied to the fame piece of goods. This is indeed always neceffary, when the finifhed piece is intended to contain a variety of colours, the different colours requiring different mordants to fix them and render them permanent.

The calico is now removed to a room called the ftove, where a certain degree of heat is given to it by means of flues, which go round the room on the infide, near the floor. In this room, it is generally continued for at leaft twenty-four hours. This is when common red-liquor has alone been printed; but if citric acid or ftrong muriate of tin has been employed, lefs time is fufficient, and for the latter feldom more than half an hour is allowed. The intention of this is to evaporate the acids ufed in the preparation of the mordants, and which might otherwife injure the texture, and alfo to fix the bafe more furely within the fibres of the cloth.

In this operation, an attention to temperature is of the utmoft importance. In general the room is kept at about 90°; but an intelligent calico-printer varies this according to the nature of the work under operation. If iron-liquor has been employed in printing the goods, it is an excellent practice to keep them for feveral days expofed to the atmofphere, after their removal from the ftove, as the blacks, pompadours, olives, and indeed every other colour prepared with that metal, will increafe in intenfity; the goods will clean better in the dung-veffels, as will be explained hereafter, and the colours will rife higher and brighter when they come into the copper of bark or madder. The iron in an acetous folution is in the ftate of the *black* oxyd; but by expofure to the air it acquires a further dofe of oxygen, and the more nearly it is made to approach to the ftate of the *red* or peroxyd, the more fit it becomes for a mordant in dyeing. It may be worth an experiment to difcover whether the colours containing iron would not be better if they were fuffered to be only a *very fhort time* in the ftove, but were hung up inftead for feveral days, expofed to a current of air at the temperature of the atmofphere; as the iron would thus acquire the oxygen flower, and confequently would be fixed more firmly within the cloth.

When the pieces have been properly ftoved, they are paffed, by means of a winch, through water at various temperatures, with a little cow-dung mixed in it. This

part of the bufinefs was formerly conducted in a very uncleanly and negligent way; but of late years fome printers have incurred a confiderable expence in the conftruction of their dunging machines, with cocks for hot and cold water attached to them, and thermometers to regulate the temperature. Thofe erected by Mr. Wright, a very ingenious calico-printer, at Strines, near Difley, are the moft complete of any we have yet feen.

The intention of the dung is to abforb and remove that portion of the mordant which is not actually combined with the cloth, and which otherwife might ftain the white or unprinted parts.

We fufpect the dung of the cow is ferviceable in another way befides that of cleanfing, though the printer may not be aware of the nature of its operation. To *clean* calicoes by immerfion in a dung-veffel, may appear to be a ftrange phrafe; but as this is the technical language of the trade, no other could be employed with propriety. It is acknowledged that madder, cochineal, and fome other dyes, produce much better colours on woollen than on cotton cloths, owing to the former being of animal, and the latter of vegetable origin. We prefume, therefore, that the dung imparts an *animal* matter to the fibres of the cotton, and that this animal matter acts as an additional mordant, and thus more powerfully attracts the colouring particles of the dye, than the mordants alone would be capable of doing. Berthollet, who analyfed the dung of the cow, found in it a fubftance partaking of the nature of *bile*.

If a piece of calico, prepared with the acetate of alumine, be divided into two parts, and the fuperfluous mordant removed from one of them by cow-dung and water, and from the other by water only, though both fluids were at the fame temperature, it will be found, on paffing the two portions through a decoction of weld or quercitron bark, that the yellow will be much more intenfe and bright in that which had been fubmitted to the action of the cow-dung. This is a fatisfactory and decifive experiment.

The procefs of *dunging* is an operation that varies in time from five to forty minutes, according to the ftyle of work. The pieces are then taken to the river or wheel, to be more effectually wafhed; after this they are paffed through tepid water, in order that the workman may be affured that every impurity is removed.

His next care is to provide a copper boiler of pure cold water, in which a fufficient quantity of madder is put, and a fire lighted underneath it. The calicoes, printed and rinfed as above, are now put into this boiler, and from the time they are immerfed, the workman never ceafes to turn the winch, fo as to pafs every part of the goods repeatedly through the liquor, till the whole acquires a boiling heat. Indeed, this operation is fometimes continued for ten or fifteen minutes after the bath of madder actually boils, when the pieces are taken out and wafhed.

Madder is one of the moft valuable drugs we have, for a variety of purpofes in dyeing and calico-printing; as it is the agent by which the beft and moft permanent blacks are produced; alfo the fineft purples, and every fhade of red from a pale pink to a crimfon. But perhaps it may not be generally known that this article improves by age. If a quantity of madder-roots be ground, and then packed tight in a cafk, fo as to exclude the air, and are kept thus for fix months, they will then dye a much better colour, and go much further than they otherwife would have done, had thefe roots been ufed as foon as they were ground.

This procefs, which is called *maddering*, has the effect of imparting all the requifite colours to the goods, by means of *one* operation, which may be thus explained. While one mordant precipitates the colouring matter of the madder to a red, another precipitates a different portion of it to a purple, another precipitates it to a black colour, and fo of every poffible fhade, from a lilac to a black, and from a pink to a deep red.

If a portion of weld or bark be added to the madder, every fhade from a brown to an orange may be produced; whereas, if weld or bark alone be employed, all colours between a dark olive and a bright lemon can be imparted to the cloth. Thefe changes are all occafioned by the play of chemical affinities, and are due to the improved ftate of chemical knowledge.

Here it may be worth remarking, that whenever it is of confequence to produce the fineft yellows or more delicate lemon colour, it is neceffary to dry the pieces in the open air, as the ftove would not fail to injure fuch colours; for ftove-drying has always a tendency to convert a yellow to an orange. It is alfo neceffary to be equally careful in the operation of dunging the mordants for thefe pale yellows; for, fhould this be done at a higher temperature than 96° or 100°, their beauty will certainly be impaired. There is another advantage in this, *viz.* by dunging at this low temperature, the dyeing may be completed even at 110° or thereabouts, which will give a much livelier colour than where a higher temperature has been employed.

The mordants generally ufed in calico-printing are acetate of iron for browns, blacks, lilacs, &c. and acetate of alumine for all the different fhades of reds and yellows.

Formerly the acetate of iron was made by digefting old iron hoops in four beer, or in very weak vinegar; but of late years it has chiefly been made with the pyroligneous acid, [if wood be fubmitted to an intenfe heat, when inclofed in an iron veffel of any kind with a proper aperture to allow the vapour to pafs, this vapour on being condenfed forms the acid in queftion, and is now known to be a kind of impure *vinegar*. The wood in this cafe is converted into *charcoal*, of which a great deal is prepared by this procefs, particularly for the formation of gunpowder,] the oleaginous impurities of which tend, in fome cafes, to improve the mordant.

Blacks are alfo produced by the nitrate of iron [nitrate of iron was not applied to calico-printing till within the laft fifty years. This difcovery formed an important era in the trade, as it afforded the manufacturer the means of varying his ftyles of work in a multiplicity of ways and forms, which, till then, were entirely unknown,] and gallic acid; the mixture is called chemical black. This nitrate of iron is made by diffolving metallic iron in a peculiar kind of aqua-fortis. Common aqua-fortis will not anfwer for this purpofe; for, though it may diffolve the iron with rapidity, part of the metal is apt very foon to precipitate; which not only weakens the colour, but leaves the remainder fo acidulous, that there is always a danger of fuch a preparation injuring the texture of the cloth.

It is, however, neceffary to remark, that the black which is formed by this folution of iron, is produced in a different way from blacks in general; for, when common iron-liquor is ufed for this purpofe, it is firft printed on the calico: and when it has been fufficiently oxydized by expofure to the air, the goods are boiled in a decoction of madder, which renders fuch parts as had been printed with the acetate of iron an intenfe black. But the black from nitrate of iron and galls is applied at once to the cloth, and is not afterwards raifed by dyeing.

The calico-printer by ufing a black ready formed is thus enabled to mix it with other colours, in cafes where by dyeing alone it could not be produced, as in conjunction with yellows and olives, raifed by weld or quercitron bark.

The acetate of alumine is prepared by a mixture of the fulphate of alumine with acetate of lead, both in a ftate of folution; fo that, on the theory of double decompofition, fulphate of lead is formed, which precipitates, while the acetate of alumine remains in folution.

Since the demand for this article has been increafed on account of the extenfion of the printing trade, it has been prepared from the pyroligneous acid by means of lime and alum. The following is the method:

The pyroligneous acid is firft paffed through a ftill, to diveft it of a portion of the tar which is always diffolved in it; it is then faturated with lime or whiting; and laftly, the acetate of lime thus formed is decompofed by a heated folution of fulphate of alumine. The refult of this double decompofition is fulphate of lime, which precipitates, and acetate of alumine, which is drawn from the fediment of the calcareous fulphate, and preferved for ufe.

And here it may be neceffary to caution the manufacturer againft a misfortune that may befall him if he be not converfant with the chemical nature of the fubftances he employs.

Magnefian lime-ftone abounds in Derbyfhire, and in fome of the adjacent counties; and fhould a maker of acetate of alumine employ fuch lime in his procefs, the article which it would produce would in all probability be entirely unfit for the ufe of the calico-printer. But we muft be more explicit.

In employing the common lime in conjunction with alum, a fulphate of lime will be formed, as mentioned above, and this being nearly an *infoluble* falt, will precipitate. But here, fulphate of magnefia would alfo be formed, which being a *foluble* falt, would remain in folution, and increafe the fpecific gravity of the liquor, a circumftance which would be very apt to occafion the deception which we are anxious fhould be avoided. If magnefian lime-ftone be employed, the liquor will appear good by the hydrometer; but, as it will contain more Epfom falt than acetate of alumine, it will be unfit for every purpofe for which it was intended.

While fpeaking of acetate of alumine, we cannot avoid remarking that the procefs which has juft been defcribed for making this mordant, and which is followed invariably by many of the manufacturers in the North, is extremely improper, on account of the lime which is employed in it, be the lime ever fo good, as that earth is very prejudicial to every fpecies of red dye. The true way of making it, though more expenfive, is that which was originally pointed out by Berthollet, and which confifts in decompofing fulphate of alumine by means of faccharum faturni, or acetate of lead.

In reverting to the remaining proceffes of the print-work, it muft be noticed, that when the goods have paffed through the weld or madder-copper, they are ufually carried to a boiler containing wheat-bran and water, in which they are winched for a confiderable time, for the purpofe of freeing the white grounds from the ftain which they had acquired from the madder or the weld. This procefs always impairs, in fome meafure, the intenfity of the colours; [branning has alfo the effect of giving a pink hue to all madder reds. But it is not *generally* known what a peculiar richnefs may be imparted to madder-colours, by raifing them with a mixture of bran and madder; that is, by mixing a portion of bran with the madder in the firft inftance. Mr. Parkes tells us, that he has fometimes produced colours in this way whofe brilliancy has aftonifhed him. The operation of the bran in producing this effect will be explained hereafter;] but it is a neceffary operation, as there is no other mode fo convenient for removing the ftain which is always given to the white part of a print by the madder, the bark, or the weld, which has been ufed in dyeing it.

It frequently is the cafe, however, that goods will not bear to be fufficiently branned to clear the whites entirely by that one operation; [the temperature at which the operation of branning is performed, is very important. If bark yellows are dyed at 100°, it is cuftomary to bran fuch goods at 115° or 120°, as it is a principle always to bran at a higher temperature than the goods are dyed at. Madder-work muft be branned at a boiling heat;] fuch goods, therefore, are partially cleanfed in the branning-copper, and are then laid on the grafs for fome days, till they become perfectly clean.

But within a few years a new method has been introduced, which confifts in immerfing the pieces for a certain time in a very weak folution of one of the bleaching falts, fuch as oxymuriate of potafh, foda, or magnefia. [A Scotch houfe of great confequence had practifed this method a confiderable time; and in the year 1812, a perfon vifited Lancafhire for the purpofe of inftructing the Englifh printers in the method.] This fimple procefs, which effects in a few minutes what would require more than as many days in grafs-bleaching, is now much practifed, and promifes very foon to fuperfede crofting entirely. This is a moft important improvement, as fome of the large printers formerly required as much land to fpread out their goods upon, as would make a farm of a very confiderable fize.

Befides the kinds of calico-printing already mentioned, there are others which it will be proper to notice in this place. Of thefe, what is called *refift-work*, is now done in confiderable quantities. It is conducted in the following manner:

A certain preparation of copper, mixed either with flour-pafte, with gum, or with pipe-clay and gum, is printed on the calico, in any fhape or of any pattern that may be defired. [The fulphate, the nitrate, the muriate, and the acetate of copper, have all been employed for preparing the refift-pafte; but the fulphate is the beft for the purpofe; unlefs a very concentrated folution of the four falts were prepared by fucceffively diffolving each of them in pure water.] When this is fufficiently dry, the goods are repeatedly dipped in the blue vat till they have acquired that depth of tint which may be required; and then, when they are wafhed, and paffed through diluted fulphuric acid, thofe parts which had been printed with the preparation of copper, are found to be a good white; the preparation having effectually refifted the operation of the indigo, [the art of making an indigo-vat confifts in forming fuch a mixture of lime and fulphate of iron as fhall moft effectually deoxydize the indigo; as indigo has no affinity for cloth in its natural or oxygenized ftate. Hence, thofe parts of a piece which are printed with a folution of copper will never be dyed blue in one of thefe vats; becaufe the deoxydized indigo becomes oxygenated the moment it touches the copper, which parts with its oxygen to the indigo, and occafions it to become infoluble, and confequently incapable of forming a dye. Thus, while fulphate of iron has the power of deoxydizing indigo, fulphate of copper, or any other falt of that metal, is incapable of retaining its oxygen, whenever it comes in contact with that fingular fubftance in a ftate of deoxydizement; and it is a curious inftance of the different degrees of intenfity by which oxygen is held by the different metals;] though all the other parts of the cloth have received a permanent dye. The various deep blue calicoes with white fpots or white figures, which are now fo common, are generally done in this way; and by a fimilar management with fubfequent dyeing in madder, weld, or

bark, figures in red or yellow are exhibited upon a blue ground.

In fome particular ftyles of work, the operation of certain colours is refifted by means of ftopping out with wax; but this is too expenfive a method to be adopted often in thefe times, when it is the object of every manufacturer to finifh his prints at the leaft poffible expence. [In printing thofe filk handkerchiefs called Bandanas, a procefs called waxing is ftill followed. It confifts in making a preparation of tallow and rofin very liquid by heat, and in printing it in that ftate with a block upon the filk. When fuch goods are paffed through the blue vat, thofe parts which are covered with the tallow and rofin are preferved from the action of the indigo, and remain white, while all the reft is dyed a faft blue. The method afterwards taken to difcharge a part of this blue, and produce yellow, orange, &c. will be mentioned hereafter.] Formerly this mode was very generally practifed, and wax [in the Eaft Indies wax is ftill ufed for preferving the whites in calico-printing] was confumed in very large quantities by this procefs. [A very fingular-looking fubftance was difcovered a few years ago near Stockport, which being handed about from one to another as an undefcribed fubftance, created confiderable intereft in that neighbourhood. Every body fuppofing it to be a natural production, fpecimens of it were fent to a variety of perfons into various parts of the kingdom, for their opinion and analyfis, and among others a portion was fent to Mr. Parkes. However, after every one had been bufily engaged in examination and conjecture refpecting this unknown fubftance, it was announced, that fome feventy or eighty years before a calico-work had ftood on the fpot where the article was found, and that this was nothing more than a large heap of of the refufe compound of flour, wax, and gum, above-mentioned.]

The reader will perceive that thefe *refifts* are employed for the purpofe of preferving certain parts of a piece white, and of giving other varieties to thofe goods in which blue is the predominant colour: but if the ground is to be white, and the piece is only to have one fmall object [a technical term, belonging to this branch of manufacture] in indigo blue, fuch as a fingle fprig, then a different management is neceffary, and the colour is imparted by a procefs which is called *pencil-blue*.

Here the indigo is deoxydized by means of orpiment, which is a fulphuret of arfenic; and formerly, whatever objects were done with it were put in by means of a pencil: hence its name, *pencil-blue*. [Pencil-blue is compofed of the following ingredients, *viz.* Ten ounces of indigo finely ground in water; twenty ounces of quick-lime in lumps; the fame quantity of potafh of commerce, or the impure fubcarbonate of this alkali; and ten ounces of orpiment. Thefe proportions require one gallon of water, and the whole is to be thickened with gum fenegal.] See COLOUR.

Another kind of procefs remains to be noticed, called chemical difcharge-work. Here the cloth is firft dyed of fome uniform colour, by means of a mixture of iron-liquor, and fome one or more of the common vegetable dyeing fubftances; and calicoes thus prepared are faid to be dyed of felf-colours. They are then wafhed and dried; and when properly preffed or calendered, they are fit for receiving any pattern whatever, according to the artift's tafte or defign.

This is generally effected by means of the mineral acids, which are previoufly compofed for the purpofe, by diffolving in them a portion of one or more of the metals, according to the nature of the dye which is intended to be difcharged, or of the colour to be produced. In doing this, care is taken that the difcharging liquor be made fo as to be capable of diffolving the iron which is contained in the dye, and which is always ufed in fuch quantity as to cover, or at leaft to difguife in a great meafure, the other colour or colours which had been employed with it, and at the fame time to act as a mordant in beautifying and fixing thefe colours.

Thus a piece treated with a decoction of Brazil-wood, and dyed black by being padded [by the term *padding* is underftood the operation of paffing the pieces from a roller through a trough containing a folution of iron, or any other mordant. *Blotching* is another term ufed in calico-printing, and is fynonymous with padding] with iron-liquor, if, when dried, it be printed with a peculiar folution of tin, the ferruginous portion of the dye will be diffolved, and the printed part will inftantly be converted from a deep black to a brilliant crimfon.

In the fame way an olive-coloured calico, dyed in a folution of iron and a decoction of weld, will as quickly be changed to a bright pale yellow; and the various drabs and flates of every fhade which have iron in their compofition, will undergo as fudden a change by the fame treatment; though the colour of the figures produced on them will depend on the materials with which the cloths were originally dyed. Even the deepeft gold colours, or ftrongeft buffs, if produced by iron only, may, by a peculiar preparation of tin, be difcharged; and fuch parts of the cloth as have been treated with this metallic folution will be reftored to their priftine whitenefs.

By fimilar management, calicoes dyed of a light blue in the indigo-vat, then run through fumach and copperas, and finifhed in a bath of quercitron bark and alum, may have figures of a bright green imparted to them. Here the green is originally formed by means of the indigo-vat and the bark, though it is enveloped by the iron of the copperas, which overcomes the other colours, till the folution of tin is applied, which removes the iron from thofe particular parts, and gives a brilliancy to the remaining colours which they would not otherwife have poffeffed; the tin being a powerful mordant for the bark, by which the yellow of the green is produced.

Again, a good felf-colour may be given to calicoes, merely by dyeing them in fumach and copperas, and then running them through an alkaline folution of annotto; and here the figures produced by the application of a colourlefs folution of tin will be of a bright orange. But it is needlefs to enumerate more inftances, as the workman accuftomed to a dye-houfe will have little difficulty in varying thefe in a thoufand ways, when he becomes acquainted with the nature of the folution of tin which he employs.

The whole of this, however, refers to that branch of difcharge-work only, where all the purpofes are attained by diffolving the iron which makes a part of the colour that is intended to be difcharged; whereas, the finer and more expenfive work is done in a different way, and by a procefs which it will be neceffary for us prefently to defcribe.

In the mean time it may be proper to remark, that there is an objection to the particular kind of chemical difcharge-work of which we have been fpeaking, namely, that it is not perfectly faft; that is, the goods produced in this way will not bear fuch frequent wafhing, as thofe which are done by the bath of madder or bark.

It is certainly an object of great national importance to give a permanency to the calico-printing of the country; [to this end great improvements have lately been made in the method of grinding madder-roots, by feparating the inferior parts, and dividing the whole into two or three different qualities. Thus the printer is enabled to apply the fineft, which in this way is made equal to Dutch crop-

madder, to his beſt work, and the other is laid by for inferior purpoſes;] and a great deal of very excellent printing is now done in various parts of the kingdom, eſpecially the beſt chintz-work and other furniture patterns. But, in what is called faſt-work, there is a great variety of qualities, and ſome of it little deſerves the name of permanent.

The mention of permanent colours reminds us of a very valuable green which was invented a few years ago by a Mr. Iſlet of London, and which deſerves to be noticed by us. This colour, which was ſecured to him by his majeſty's letters patent, was produced by printing ground indigo, mixed with a peculiar kind of ſolution of tin, and in then faſtening the indigo within the fibres of the calico by means of that proceſs, which is well known to printers by the technical deſignation of *china-blue dipping*. [China-blue is produced thus: Indigo ground fine, and then thickened, is printed upon the cloth, and afterwards it is diſſolved, and chemically united to the fabric, by alternate immerſion in a ſolution of ſulphate of iron and in lime-water. A deſcription of this proceſs has already been given very much in detail, in our eleventh volume, part ii. under the article DIPPING, in *Calico-Printing*.] After this the goods are to be dyed in a copper of bark or weld, which converts the blue to a green, and the whites are to be cleanſed by croft-bleaching, &c.

Upon this very ingenious proceſs, Mr. Parkes has the following obſervation. "Having," ſays he, "formed a very high opinion of this invention, I procured ſeveral interviews with Mr. Iſlet, ſoon after he obtained the patent, and from him was fully informed of the whole proceſs. — This I have ſince repeated for the purpoſe of verifying the detail in all its branches; and I am ſatisfied that it is one of the moſt beautiful and permanent colours that has ever been fixed upon cotton."

There is, however, another mode of producing very beautiful blues which has been much practiſed lately, and therefore deſerves notice. This conſiſts in printing ſome ſolution of iron, and then paſſing the goods through a very dilute and neutral ſolution of pruſſiate of potaſh. The pruſſian blue which is thus formed upon the cloth may be rendered tolerably permanent by a variety of expedients, and this by means of any of the yellow dyes may afterwards be formed to any ſhade of green or of olive.

In returning from theſe digreſſions we muſt not forget to revert to that other kind of diſcharge-work which we have engaged to deſcribe, and which we will now attempt as conciſely as is conſiſtent with perſpicuity and correctneſs.

Here, the agent which is employed is the citric acid, and this is uſed in various ſtates of concentration according to the purpoſe to which it is to be applied, and the ſtrength of the ground intended to be diſcharged. It is chiefly employed for the production of white figures upon ſelf-coloured grounds produced by madder and ſundry other dyes. For this intention the acid, in whatever ſtate of concentration it may be, is mixed with either gum or with paſte, [when citric acid is uſed for reſiſt-work, it is always mixed with gum ſenegal and pipe-clay. The clay gives it a greater body, and likewiſe acts mechanically as a reſiſter,] to a proper conſiſtency for the block, the plate, or the cylinder, and from thence it is transferred to the piece; and wherever it attaches, the mordant, whether iron or alumine, is diſcharged, and a delicate white ariſes in its ſtead. [It ſhould be underſtood, that the diſcharge is printed upon the mordants before the goods are dyed. In uſing citric acid for this purpoſe, a portion of one of the mineral acids is ſometimes mixed with it.]

The acid here referred to is produced from the juice of limes or lemons, and formerly it was not employed by the calico-printer until it was reduced to the utmoſt point of concentration, and appeared in a cryſtalline form. Even then, it was not thought ſufficiently pure, but was diſſolved again, and rediſſolved and recryſtallized, till it became as white and pellucid as any other pure ſalt in a cryſtallized ſtate, and was then generally ſold for 36*s*. the pound, at which high price it could only be employed on the beſt ſtyles of work. Now, however, it is oftener uſed in the brown, or firſt ſtate of cryſtallization; and ſome of the larger printers purchaſe lime juice, and concentrate it themſelves; and in many caſes, they uſe it largely both for diſcharge and reſiſt work, without ever cryſtallizing it at all. More on this ſubject may be ſeen in Mr. Parkes's Eſſay on Citric Acid, in vol. iii. of the Chemical Eſſay, page 1—118.

This mention of diſcharge-work by citric acid, [Mr. Thomſon, who has a print-work near Clitheroe, has taken out a patent for diſcharging the Turkey-red dye by means of the citric and oxymuriatic acids; and the work executed in this way has a very pleaſing effect,] reminds us of another ſpecies of diſcharge, which is employed by the printers of Bandana handkerchiefs, and which we are under the promiſe of noticing before we conclude this memoir.

The agent which theſe printers employ is the nitrous, and ſometimes the nitro-muriatic acid. It is uſed for the purpoſe of putting yellow figures upon blue ſilk handkerchiefs. The following is the proceſs which is principally adopted.

Aqua-fortis, or nitro-muriatic acid, of ſuch a ſtrength as is ſuitable for the kind of blue which is intended to be diſcharged, is mixed either with gum tragacanth, or with flour paſte, to a proper conſiſtence, and in this form it is printed on the ſilk, by means of a common block, on which the intended pattern is cut. The conſequence of this is, that wherever the acid attaches, there the original colour is diſcharged, and a yellow dye is produced in its place. The pieces are then ſteamed, by paſſing them over a veſſel containing boiling water, which gives brilliancy to the colour and finiſhes the operation.

If a ſtronger dye than the uſual yellow, or even a deep orange be deſired, all that is neceſſary is to immerſe the goods, for a moment, in lime-water, or in a ſolution of lime and potaſh; and by varying the proportions of theſe ingredients a great variety of ſhades may be produced.

Recollecting, however, that this is a paper profeſſedly on calico-printing, we muſt not deviate too far from the path we have preſcribed; otherwiſe, there are many proceſſes in the printing of ſilks which are curious and intereſting, on which we might copiouſly expatiate. The Bandana handkerchiefs which are printed upon cotton in imitation of India goods, are produced by a very different proceſs, and which we have already deſcribed under the article DISCHARGING *of Colour*, in vol. xi. part ii.

Having been ſpeaking of yellows, it may be worth mentioning, that there is a mode of producing yellows on calico which is not very frequently practiſed, and yet has a very good effect. The proceſs is as follows:

A ſtrong decoction of bark, thickened with gum tragacanth, is to be mixed with a portion of very pure muriate of tin, and this, when printed with the uſual management, will produce a colour of great brightneſs and durability. We mention this the rather, becauſe very many pleaſing effects may be obtained by this method which cannot be produced in the uſual way, by means of the acetate of alumine, and any of the yellow dyes that may be employed with it.

There is one very important advantage which this mode

poffeffes, *viz.* that fhould it be neceffary to pad a piece in diluted acetate of alumine to obtain a pale lemon ground, the yellow figures, previoufly done by the above procefs, will not give out any part of their colour to the fecond mordant; whereas, whenever a ftrong yellow has been produced in the common way, the pattern is very apt to fpread and become irregular, and oftentimes to ftain the ground, when the piece comes a fecond time into the acetate of alumine.

Obferving that the treatife from which we have made fuch copious extracts, contains no particular directions for the preparation of that fuperior kind of calico-printing called chintz-work, we applied to Mr. Parkes upon the fubject, and he has furnifhed us with an original communication to fupply that deficiency, which is as follows:

The term chintz-work is defcriptive of that kind of calico-printing which is employed for beds, window-curtains, and other furniture, and it differs more in the richnefs and variety of the colours, than in any other circumftance.

In relating the proceffes by which thefe beautiful prints are produced, we fhall fuppofe the calico to be already properly bleached and calendered, ready to receive the impreffions of the block. The firft thing then to attend to is, to apply the mordant for the colour which is intended to be imparted in the firft inftance. Thus if a black be defigned, a mordant of acetate of iron, commonly called iron liquor, is thickened with gum, and printed upon the cloth in any pattern that may have been felected for the purpofe. If this fame mordant be diluted with water, it will form a proper mordant for a purple;, and the fame, ftill further diluted, will, when it comes into the dyeing copper, form a lilac. In this way, all the varieties of fhades, from a pale lilac to a ftrong purple, and from purple to a black, may be produced by acetate of iron diluted with various proportions of water, and then dyed with madder.

In like manner, a colourlefs folution of acetate of alumine thickened with gum or flour pafte, forms a mordant for dark red; if diluted with water it makes a common red; and by diluting it further and further every fhade of pink may be produced. Again, by the admixture of acetate of iron, and acetate of alumine, a mordant for chocolate colours, maroons, &c. is formed, either approaching to the purple or the red, according to the admixture; that is, according to the proportion of either of thefe original mordants which may predominate in the mixture.

When thefe feveral mordants have been printed upon the calico, they are allowed to dry for two days or more in a ftove or drying-houfe; they then go through the operation of dunging, which confifts in rinfing them in warm water, in which a little cow-dung is diffufed, as has been already defcribed. When the pieces are fufficiently dunged, which is not the cafe till all the fuperabundant mordants are removed, they are well-wafhed in clean water, and then boiled in a decoction of madder, until the madder-bath is exhaufted. In confequence of different mordants having been applied to the cloth, this one boiling in the madder-liquor will at once produce all the colours above-mentioned. When the pieces are thus dyed, they are to be rinfed in cold water, and laid upon the grafs to bleach. By this expofure to the air for a few days, the whole of the ground to which none of the mordants had been applied, will become perfectly white.

The proceffes which have now been detailed, will produce what is called *common* chintz-work; but if it be defired to make the goods ftill richer, by the addition of yellows, bright olives, drabs, &c. the cloth muft undergo another feries of operations, which may thus be defcribed.

Upon thofe parts of the calico which ftill remain white, any of the above mordants may be printed, according to the effect defigned to be produced, after which all the preceding managements are to be repeated, except that inftead of boiling in a decoction of madder, they are to be immerfed for about half an hour, more or lefs, in a warm decoction of quercitron bark, the *Quercus nigra* of Linnæus; a moft important dye-wood, introduced by Dr. Bancroft, and which is found to give out a much brighter colour to *tepid* water, than it does when treated with *boiling* water, or with water nearly approaching to that temperature.

The effect produced upon thefe prints by an immerfion in a lukewarm decoction of this American bark, will be quite different from that produced by the madder; upon thofe parts of the cloth where the mordants have been printed which before produced a black, a dark olive only will be apparent, and inftead of pompadours will be drabs, and inftead of reds we fhall have yellows, which will vary in intenfity according to the ftrength of the aluminous mordant.

Again, a further variety may be given to thefe prints, if the yellow mordant, or acetate of alumine, be applied to any of the colours which have already been dyed with madder; but this muft be done before the pieces are immerfed in the decoction of bark. This application will convert the reds and pinks into different fhades of oranges, and the lilacs into cinnamon colours. By means of thefe different proceffes an endlefs variety may be given to the goods, and a calico-printer of tafte will never be at a lofs how to produce a pleafing effect, whatever may be the patterns which he has to imprint upon the cloth. This fecond immerfion in the dyeing veffel will, however, give a yellow tinge to the remainder of the whites, but a fhort expofure on the grafs will obliterate it.

When chintz furniture-prints are defigned to have as much variety of colouring as poffible, a part of the remaining white is often coloured blue or green, or of any fhade between thofe colours, by a ftill different procefs. This is done with what is called pencil-blue, which is a preparation that has already been defcribed. The blue is given by putting in the prepared indigo with a pencil; and the green is produced by pencilling fome of the fame colour over certain parts of the pattern which has already been dyed yellow. When thefe colours have been imparted, the printing is faid to be finifhed, and the pieces are hung up to dry for at leaft twenty-four hours, after which they are rinfed thoroughly in cold water; and when they have been dried with care, they are properly calendered and put up for fale.

Nothing now remains but to notice an improvement which has been made of late years by the introduction of *cylinder-printing*, and which has the advantage of fuperior accuracy and neatnefs, as well as of great expedition.

The machines which effect this are rather complicated and expenfive; but they are fo contrived that the cylinders on which the patterns are engraved, furnifh themfelves with colour during their revolutions; are kept clean by a fteel knife, or *doctor* as it is called, paffing over their furfaces the moment they have charged themfelves with the thickened colour; and they have fuch a preffure given to them, either by means of fcrews or levers, which can be tightened or flackened at pleafure, that the whole furface can be made to depofit its colouring matter with the greateft certainty and exactnefs on the cloth, while this rolls over it in fucceffion, from one end of the piece to the other.

Thefe cylinders, which are made of copper, are from eighteen to forty-two inches in length, according to the width of the calico to be printed, and three and a half to

five inches in diameter; and these massy rollers have the patterns enchased upon their surfaces, in the same way as a pattern is cut upon a flat plate of copper, that is intended to be employed in copper-plate printing. As these cylinders are made with plates of copper hammered into a circular form and joined by brazing, great loss has sometimes been sustained by the engraving giving way upon the brazed joint. To obviate this, a patent has been lately obtained for boring the copper cylinder from the solid metal in the modern way of boring cannon.

Many of these machines are now contrived so as to carry two of these cylinders, each of which has a trough of colour attached to it, by which means two different colours may be printed on the same calico, at one and the same time.

Mr. Adam Parkinson of Manchester has lately invented a machine capable of printing at one time, by means of one cylinder and two surface-rollers, or by two of the former and one of the latter, three distinct colours.

These machines have not only the excellence of printing more correctly than can possibly be done by means of the block, but the saving of time and labour which they afford is great indeed. A piece of calico which would take a man and a boy three hours to print with one colour, or six hours to finish with two colours, may by this means be done in three minutes, or three minutes and a half, and then much more completely than could even have been imagined before the introduction of this invention.

Besides these cylinders there are others which are called *surface-machines*, which contain cylinders of wood, and which have the pattern formed upon their surfaces in relief, exactly similar to the blocks already described. These are employed in particular styles of work, especially in light ground-work, and for certain kinds of resist and discharge work.

In light work, the white grounds are apt to be soiled by the cylinders: hence surface-machines were contrived, and these are not liable to the same objection. Cylinder-machines are more commonly employed in those styles which are full of colour and leave but little white.

It must be obvious to every one who is acquainted with the subject, what an astonishing facility these machines have afforded to the production of printed calicoes; and also what an advantage they give to the British printer in foreign markets.

But we cannot conclude without expressing our fears, that even these facilities may eventually be the means of doing a serious injury to the trade, and of destroying that confidence in the goodness of British prints, which has hitherto been generally felt in every market on the continent, and also in every part of the New World, wherever they have been introduced. We refer to that mode of printing which has lately been adopted, and which consists in precipitating the colouring matter from logwood, and from other *fugitive* dyes, and in printing these on the cloth, without any mordant or previous preparation whatsoever. Thousands of pieces of this sort have been finished at the low rate of one penny the yard, including every expence of colour, paste, and printing. These articles, it will scarcely be credited, are dried up immediately from the printing-machines, and are shipped abroad, without even being washed off.

To *wash off* is a technical phrase. It means the soaking and rinsing the pieces in water, in order to dissolve and remove whatever gum or paste had been employed with the colours in printing them.

Such goods, wherever they go, must produce great dissatisfaction; for they will neither endure the rays of the sun nor moisture. The first shower of rain to which they may be exposed, will not fail to wash out the pattern, and reduce them to a worse state than that of plain white calicoes.

In the reign of queen Elizabeth, an act was passed to restrain the use of logwood in dyeing, on account of the fugitive nature of its colour; and if this degrading kind of printing be continued, the interference of the legislature will again become necessary, or the foreign trade will, from this cause alone, be entirely lost to the country.

PRINTING, *Cylinder*. See the preceding article.

PRINTING *on Porcelain*. The art of printing, particularly as it applies to books, has, from its incalculable benefits and vast importance, excited at once the profound admiration and gratitude of the world; and this inestimable discovery has been claimed by several individuals, alike anxious for the honour of giving to mankind at large the advantage of a rapid and economical diffusion of delight and instruction. The *first* idea of *types* was very probably given by the *Roman potters*, who were in the habit of stamping their names in *raised* characters on their vases, &c. The letters on this plan were, in fact, *models* of the types used by the first printers; and it appears singular that the idea of adapting such models by the medium of ink, to the common purpose of multiplying words and sentences, should not have come into use until about the year 1442.

It will appear, on consideration, still more singular, that after the introduction of engraving on wood and copper, (which was in use at the same time with letter-press printing,) the art of transferring impressions of ornamental designs, from the copper-plate to the surface of porcelain or pottery, was not discovered till about the year 1760.

The Royal Porcelain Works in Worcester, belonging to Messrs. Flight, Barr, and Barr, are the only establishment that claims the honour of inventing this admirable and ingenious process. We can find no mention of this art in the annals of this or any other country prior to this period. It was practised with great success for many years in the works alluded to; and besides the demand for home consumption, large quantities were exported to Holland. In the year 1788, his present majesty Geo. III., and his royal consort the queen, with the princess royal, the princess Augusta, and the princess Elizabeth, visited the Worcester Porcelain Works, and particularly noticed this ingenious branch of the art of decoration. The royal party were much gratified by the compliment paid them, in the striking off impressions from two copper-plates with the likenesses of the king and queen, which had previously been engraved by direction of the proprietors, in order to exemplify the nature of the operation. The secret of the printing was, about the year 1781, conveyed from the works at Worcester into the potteries of Staffordshire, and has proved of infinite service in extending this branch of national commerce, and affording employment to the numerous population in that part of the country. The common British blue and white printed earthen-ware is now held in high esteem in foreign countries, from its cleanly and neat appearance, besides its being in general use at home. This art is certainly best confined, as in the present day, to the inferior fabrics, such as earthen-ware, as the material on which the print is made is reasonable, and can be rendered at a price which suits the convenience of the consumer for all common purposes. The method, as invented and adopted by the original proprietors of the Worcester Porcelain Works, is as follows:—The engraved copper-plate having

firſt been warmed on the ſtove, is prepared to receive the colour, which, being previouſly mixed with oils of a proper conſiſtency, is then rubbed into the engraved lines, and the ſuperfluous quantity of colour is carefully cleaned from the ſurface of the plate. The paper, which is very thin, and manufactured for the purpoſe, is then laid on the plate, and delivered to the preſſman, who places it on a plank covered with warm flannels, and being fixed between two iron cylinders, it is drawn through by turning a wheel, exactly on the plan practiſed in taking off copper-plate prints. The paper bearing the clear-coloured impreſſion is now removed from the copper-plate and delivered to the printer, who fixes the piece of porcelain in a vice, to keep it ſteady; and the printed paper is then rubbed with a wooden tool, covered with flannel, till the impreſſion is completely tranſferred to the ſurface of the biſcuit, or *unglazed* porcelain. The operation of rubbing on the impreſſion being completed, the porcelain, with the paper left on the ſurface, is thrown into a tub of cold water, and in a ſhort time the paper delivers itſelf, and leaves the print. The ware is now placed out to dry, and is afterwards carried to the kiln, where the impreſſions are burnt in. It is then dipped in the liquid vitreous ſubſtance called the glaze, is burnt a ſecond time, and the colour, which is the oxyd of cobalt, (and moſt generally uſed,) comes out a neat blue, perfectly ſecured under the glaze.

An *improved method* of printing, comparatively of very recent invention, was introduced under the direction of the late Martin Barr, eſq., and is now carried on in the Porcelain Works at Worceſter, and is much admired for the *excellence* of the engravings, and the great beauty of the impreſſions. On this plan, the printing-preſs and ſtove are not neceſſary, as the engraved plate is charged with a prepared oil by the printer, who cleans the ſurface of the engraving with the hand; and inſtead of paper, a *bat of glutinous conſiſtency* is cut out and laid on the copper-plate, and is ſo ductile as to adapt itſelf to the form of any veſſel intended to be printed; and by the ſimple preſſure of a ſtuffed leathern ball *with the hand*, produces a perfect impreſſion of the ſubject *in oil* on the ſmooth ſide of the bat. The ware being rubbed dry and clean, the bat is now gently preſſed with the leathern ball on the *glazed* ſurface of the porcelain, and when removed the impreſſion appears complete, *but only in oil*. The colour, in form of a powder, is then lightly moved over the oil impreſſion with a piece of carded cotton, and the print completely cleared of all that is ſuperfluous. The porcelain is afterwards carried to the enamellers, who finiſh the deſign by adding ſome decorations in gold; and it is then paſſed through the enamelling kiln, where the oil is evaporated by the fire, and the colour, which is always a mineral preparation, unites firmly with the glaze, and becomes perfectly durable as the tints laid on with the camel's-hair pencils by the painters. The great advantage of this plan is, that the engraving can be executed *much finer* for the ſmooth ſurface of *the glazed porcelain*, than for the coarſer blue and white prints, (which are laid on the *rough unglazed ſurface*,) as the glaze is capable of receiving the *fineſt touch* the artiſt can put into his engraved plate. Meſſrs. Flight, Barr, and Barr, the proprietors of theſe works, have in conſequence introduced beautiful engravings of figures from the antique, beſides deſigns in landſcapes, flowers, ſhells, &c. which reflect no ſmall degree of credit on this branch of the art of printing. Conſiderable quantities have been exported to the Eaſt and Weſt Indies; and where economy is the object of the conſumer, this ſtyle of decoration ſuits very well, however deficient in richneſs of effect and elegance, to the more elaborate production of enamelled deſigns, executed in theſe intereſting and highly-reſpectable works.